THE UNIVERSITY OF ALBERTA

"THE RELATIONSHIP OF PHYSIOGRAPHY TO THE HAIL DISTRIBUTION PATTERN IN CENTRAL AND SOUTHERN ALBERTA"

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR

THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF GEOGRAPHY

by

Grace L. Powell

EDMONTON, ALBERTA

May 1, 1961.

THE RELATIONSHIP OF PHYSIOGRAPHY
TO THE HAIL DISTRIBUTION PATTERN
IN CENTRAL AND SOUTHERN ALBERTA

ABSTRACT.

This study was conducted in an attempt to detect what relationships, if any, there are between physiography and hail frequency patterns in central and southern Alberta.

Data were obtained from the Canadian Hail Underwriters' Association, the Alberta Hail Insurance Board, and the Alberta Hail Studies Project. The material was plotted to determine the distribution and spatial relationship of hail for the years 1951 to 1960. The pattern thus formed was analyzed and compared with the physiographic features of the areas receiving hail three or more times during the period.

It was found that the incidence of hail does, in fact, bear some relationship to certain physiographic features. Firstly, hail appears to occur more frequently on the lee slopes than on the windward slopes. Secondly, the gentle slopes, broad flat depressions, and fairly flat valleys

have a higher average of hail than do the steeper slopes. Thirdly, the sections around lakes have less hail than many other sections. This may be due in part to the stabilizing effect of the lakes on the local weather conditions. Finally, the crests of hills or ridges have hail less frequently than the flanks of the same hills or ridges.

The hailstorms appear to follow distinct tracks quite regularly within the area. These tracks vary depending on the relative position within the system but vary little from year to year in any specific location.

Studies of other hail areas may show that similar relationships exist elsewhere, and this could prove to be an important clue to a better understanding of some of the problems relating to hail.

ACKNOWLEDGEMENTS

The writer wishes to thank the many people without whose assistance and co-operation this study could not have been completed. To the Canadian Hail Underwriters' Association in Regina, and the Alberta Hail Insurance Board at Calgary for making the claim statistics available; to the "Stormy Weather" Bureau at McGill University for the data of the Alberta Hail Studies Project; to the Alberta Research Council for their financial assistance; to Professor R. W. Longley and Dr. A. H. Laycock for their stimulating suggestions and advice; and finally to Miss Joyce Powell for her assistance in preparing the final copy I should like to extend my heartfelt appreciation.

TABLE OF CONTENTS

TABLE OF CONTENTS

(Cont'd.)

LIST OF MAPS

LIST OF MAPS

(Cont'd.)

LIST OF TABLES

LIST OF ILLUSTRATIONS

THE RELATIONSHIP OF PHYSIOGRAPHY TO THE HAIL DISTRIBUTION PATTERN IN CENTRAL AND SOUTHERN ALBERTA

CHAPTER I. INTRODUCTION.

OBJECTIVES OF THE STUDY.

Hail is the most destructive form of precipitation. It is often responsible for serious damage to crops and greenhouses. It also causes damage, at times, to less vulnerable objects, pitting the paint on cars, ruining roofs, and even killing livestock in the field. Hail is generally associated with a thunderstorm but occurs with a few individual storms. When a thunderstorm is accompanied by hail, the stones fall over only a fraction of the area on which rain occurs. There seems to be a tendency for some areas to receive a greater frequency of hail than neighbouring areas. The regional and local variations in the frequency of hail and in the amount of hail damage are startling. Although the general synoptic weather pattern plays a large part in the development of thunderstorms and hail, it has been thought that the local physiography or physical features may govern, to some extent, the boundary between hail and non-hail areas.

The purpose of this study is to analyze both the hail frequency pattern of central and southern Alberta and the physiography of the hail areas to see if there is any relationship between them. To achieve this objective two steps were necessary. The first of these was to determine the actual incidence of hail for the individual sections within the various townships and ranges The second step was to analyze the physiography of the sections receiving hail to see if a relationship can be detected for the area in Alberta under study.

The path of the individual storms is generally longer than it is wide, resembling a swath when plotted on a map. The length and width of the individual storms vary considerably, so does the precise location of these paths or tracks as they are more commonly called. They do, however, have a directional tendency and over the years these hail tracks result in some areas having a higher frequency of hail than other areas relatively near-by. Map 2 shows the frequency pattern which has resulted from the reported storms during the years 1951 - 1960. The areas where there was a concentration of sections with an incidence of three or greater were analyzed for the purposes of this study.

Why Study Hail?

Hail is not a rare or modern phenomenon. For centuries men have tried to find the cause of hail as well as possible ways to suppress it. For ages, until forbidden by Papal decree, there was a practice in Europe of ringing church bells during the thunderstorms in the belief that this would prevent hail. "Later a form of hail cannon was widely used, on the theory that shooting vortex rings into the upper atmosphere would break up the ascending and gyrating currents that were supposed (at the time) to cause hail." [1] Although these methods were not successful they were in vogue for a considerable time, probably due to the human tendency to try anything to avert disaster.

Records showing the damaging effects of hail date to pre-Christian days for various writings as far back as the 5th century B. C. show that in the Mediterranean regions of Europe hailstorms wrought havoc with vineyards, orchards, cereal crops, and

---

1. Flora, 1956, p. 15.

livestock. "Aristotle (384-322 B. C.), in his 'Meteorologic', discusses hail and the causes of its formation. The artist, Benvenuto Cellini, tells of a terrific fall of hail which he encountered while traveling with some companions 'about a day's journey from Lyons.'" [2]

One of the earliest accounts of hail in North America is a description by the Spanish explorer of the American Southwest, Francisco Vasquèz de Coronado, of a severe hailstorm which struck his expedition in 1541, apparently in an area within what is now Texas. He relates how the hail caused his horses to stampede and extensively damaged his equipment. Since that time more and more records have been kept on hailstorms including details pertaining to the individual storms as well as estimates of the extent of damage. The amount of damage caused to crops as well as buildings, automobiles, and airplanes is often so high that it is almost unbelievable. For example, "at Denver, Colorado, twenty carloads of glass were required to replace losses after a severe hailstorm on May 30, 1948". [3]

---

2. Ibid., p. 14.

3. Ibid., p. 4.

Windows after an Oklahoma hail-storm. This storm occurred near Moore, Oklahoma, April 28, 1956. Courtesy Bea Bragg, Norman Transcript.

What hail can do to a shingle roof. Near Weatherford, Oklahoma, July 1, 1940. Courtesy U. S. Weather Bureau and the Oklahoma Publishing Company.

Flora, Snowden D., Hailstorms of the United States, 1956.
between pages 74 and 75.

Remains of a promising corn crop in Marshall County, Kansas, after a hailstorm on July 23, 1944. The storm swept three paths of destruction through one of the important corn-producing areas of Kansas.
Courtesy Byron E. Guise.

Flora, Snowden D., Hailstorms of the United States, 1956.
between pages 74 and 75.

> Hail is more destructive than tornadoes. A single hailstorm, striking a city during business hours, can in a few minutes result in a loss of a million dollars or more to parked automobiles alone. Wichita, Kansas, in a period of twenty-four months had two violent hail and wind storms that caused losses of nine to fourteen million dollars each. In many parts of the High Plains between the 100th Meridian and the Rocky Mountains hail destroys, on the average, 8 to 10 per cent of all crops annually. Hailstorms constitute one of the major risks of aviation.
>
> With the value per acre of crops rising steadily and with more and more automobiles and buildings as targets, losses from hail damage will increase correspondingly. Since hailstorms occur throughout the United States and over most of the world's land surface, hail is a matter of crucial importance to a great many people.[4]

From an economic standpoint alone a study of hail is significant. This is especially true if the study helps to solve some of the mysteries surrounding the formation and occurrence of hail. As the cause or causes of hail are not fully understood, it is important to study its occurrence from as many different aspects as possible. Even negative results will be helpful insofar as they will help to narrow down the field of investigation.

---

4. *Ibid.*, p. vii.

Some Characteristics of Hail Occurrence

One of the characteristics of the distribution of hail is an apparent relationship between the physiography of an area and frequency pattern within it. This feature is the one analyzed in the study made here. One section may average hail two or three times a year while another section only a few miles away will have an apparent immunity to hail. On the section level, a farmer will identify one field as having frequent hail and another as being hail free. The individual hailstorms appear to occur along certain tracks following roughly the same pattern from year to year. The tracks themselves are not fixed but often follow the same route, giving a higher relative frequency to sections within them than those outside. This tendency to have hail occur repeatedly along one track may be related to the physiographic features of that area.

Since hailstorms do occur in narrow tracks their frequency is generally small when a specific location is considered. Lemons [5] computed the

----

5. Lemons, 1942, p. 65.

average numbers of hailstorms for specific locations and found the following for the period he studied: Swift Current had 1.1 hailstorms per year, Prince Albert 1.3, and Winnipeg 1.7. [6] There are many places where the average hailstorms per year is higher but any specific location averaging more than one destructive hailstorm a year suffers a high loss in crops and property damage. Southeastern Wyoming and western Nebraska average nine hail days per year while eastern Nebraska averages less than four hail days per year. [7]

> Since hail occurs with thunderstorms it might be assumed that areas of frequent thunderstorms would have more hail. Roth reports that in Tampa, Florida, one storm in 175 has hail while in Dodge City, Kansas, one in 10 has hail. Hence, Tampa with twice as many thunderstorms per year (90) has one hailstorm every two years while Dodge City with only 45 thunderstorms has over 4 hailstorms per year.
>
> Three stations in Alberta were checked for similar information for the period 1950-54. The results are shown in Table 1. These stations average 21 thunderstorms per year and 3.5 hailstorms. One thunderstorm in 6 produced hail. [8] (It must be noted that a case of reported hail in this table is not necessarily severe enough to cause crop damage.)

---

6. It should be noted here that he was dealing mainly with destructive storms as data for the non-destructive storms were not available. In fact, the coverage of the non-destructive storms has been included only since 1956 when the Alberta Hail Studies Project began its detailed studies of the Alberta hailstorms.

7. Flora, 1956, pp. 127-176.

8. Thompson, 1956, pp. 3-5.

TABLE 1 [9]

Thunderstorm and Hailstorm Data for Alberta

Station	Years	Thunderstorms	Hailstorms	Ratio of Hail to Thunderstorms
Lethbridge	1950-54	98	Incomplete	
Lethbridge	1954	21	3	1/7
Calgary	1951-54	99	20	1/5
Edmonton	1950-54	104	12	1/9
Alberta Average	Per Year	21	3.5	1/6
Dodge City Average	Per Year	45	4.5	1/10
Tampa Average	Per Year	90	0.5	1/175

The time of year in which the hail occurs is an important consideration when studying its frequency. A great many of the reports are based on crop losses. Therefore, hail during the growing season is usually reported, but that at other times of the year is generally ignored. "The maximum hailstorm frequency moves northward from the Gulf of Mexico early in the

9. Ibid., p. 5.

spring, reaching Alberta in late June. Lemons reported that June 15-30 showed the greatest hail frequency in Montana. The period July 1 to August 15 is considered to be the hail season in Alberta." [10]

In some areas a third characteristic is apparent and this is a "marked correlation with the terrain (elevation). For example, under synoptic situations that appear to be more or less similar the hailstorms are more severe at Cheyenne (6,000 feet) than at Omaha (1,000 feet)".[11] Even more striking than this is the difference in frequency in Kansas between the eastern and western sections of the state."The hail risk measured by the crop-loss factor,[12] increases steadily from less than $1.00 in some eastern counties where elevations are below one thousand feet to between $8.00 to $12.00 in many western counties where elevations exceed three thousand feet." [13]

---

10. Ibid., p. 7.

11. Petterrssen, 1956, p. 171.

12. The "loss ratio" is the expression in dollars and cents of an insurance company's loss per one hundred dollars of insurance written in a particular region.

13. Flora, 1956, p. 101.

This aspect of the problem cannot be studied conclusively in Alberta for the elevations of the sections reporting hail do not show the large amount of local relief which was evident in the examples cited above. [14]

An additional factor that appears to be of significance in the study of the distribution of hail is the fact that the areas where hail is most frequent are located on the lee side of a mountainous region. The hail pattern in North America confirms this. The prevailing winds are westerly and the areas with the highest frequency are found along the eastern flanks of the Rockies. Colorado and Wyoming have a relatively high frequency of hailstorms per year. There is a slight decrease in the average in Montana but it rises again in Alberta. In several other areas throughout the world hail appears to be more frequent in the locations to the lee of a mountain range than to the windward side of the same range. For example, the hail region in New Zealand is in the lee of the Southern Alps. The prevailing winds are westerly and

---

14. The elevation of the areas studied here were noted in each case. However, no conclusions could be reached based upon this information. See Appendix "B", section 2 of each subdivision.

the hail frequency is higher on the eastern side of the mountains, in Canterbury in particular, [15] than on the western. The country near Timaru and Temuka is not unlike some parts of Colorado and Wyoming. The hail incidence is high in both locations. During the dry northeastern monsoons in India hail is most frequent and often severe. The hail occurs on the southern or southwestern (or lee) flanks of the Himalayas and also in the southern portion of Hyderabad which is at a lower elevation than the northern sections of the state. [16]

Is Alberta Representative?

Of the four characteristics discussed above three have direct application to Alberta. The first was the tendency for the hailstorms to follow similar tracks. Within Alberta certain directional tendencies may be observed. These are largely determined by the relative location of the individual storm within the system as a whole.

---

15. Private communication with Mr. Leslie Talbot, who has a farm near Temuka, New Zealand.

16. Flora, 1956, p. 186.

The hail season for Alberta occurs during the growing season so that crops are often seriously affected by the storms. During the past ten years hail has destroyed more than $220 million worth of crops.[17]

The factor of elevation cannot be thoroughly investigated in Alberta as has been noted earlier.

The hail areas in Alberta are on the eastern (or lee) side of the Rockies as the prevailing wind direction for the province as a whole is from the west. Therefore, Alberta is a significant region for a "pilot study" relating physiography to the actual distribution of hail.

> The physiography of Alberta and Saskatchewan show marked differences. Alberta is bounded on the west by the Rockies and a foothills zone. Experience in the U. S. A. shows that the foothill area is a breeding ground for strong convective activity and hailstorms. The Canadian Hail Underwriters' Association consider that fine detail in hail experience indicates that hills trigger hailstorms affecting downward locations in Saskatchewan. This effect probably finds its counterpart in Alberta much overbalanced by major terrain problems provided by the Rockies and their foothills.[18]

----

17. Computed from estimates of damage appearing yearly in the <u>Alberta Gazette</u>.

18. Thompson and Smith, 1960, p. 6.

It can be seen, therefore, that the problem of the effect of the local physiography on the distribution of hailstorms concerns all hail areas, especially Alberta. This problem has prompted the investigation and study made here.

Method of Conducting the Study

The incidence of hail during the past ten years, 1951-60, has been plotted and the main tracks and areas noted. The areas receiving hail most frequently were examined in detail with respect to the following factors:

1. the local relief of the area, including the gradient of the slope,
2. the elevation of the area,
3. the exposure or aspect of the slope,
4. the proximity to water bodies, and
5. the trend of valleys or ranges of hills.

The statistical data have been obtained from the Canadian Hail Underwriters' Association at Regina, the Alberta Hail Insurance Board at Calgary, and the Alberta Hail Studies Project through the Macdonald Physics Laboratory at McGill University in Montreal.

The Alberta Hail Studies Project, composed of three separate agencies, was formed in 1956. Its aim was to study the possible cause as well as the effect of hail in Alberta. The three agencies are the Macdonald Physics Laboratory at McGill University, the Research Council of Alberta, and the Meteorological Branch of the Dominion Department of Transport. At the conclusion of each year the data which they had collected for the hail season that year were forwarded to the "Stormy Weather" Research Group for further analysis. These data, each report on a separate card, were also used for this study.

The total number of times that hail has been reported in the individual sections has been tabulated for the period without regard to the individual years in which they occurred. The major storm tracks have been examined where they serve to give a more complete understanding of the pattern of distribution. The yearly tracks are important due to the fact that the hail seems to follow preferred routes or "hail roads".[19]

---

19. The term "hail roads" was used by the Austrian meteorologist Prohaska. He spent many years studying the incidence of hail and discerned these tracks or "roads" in his study of the 1905 hail season in Austria. His findings were published in 1907.
Weickmenn, 1953, p. 104.

As in the case of normal thunderstorms, Prohaska found that preferred routes do, in fact, exist. From the detailed analysis of the hail distribution on a yearly basis a similar pattern is found to exist in Alberta. One of the characteristic features of the "hail roads", as observed by Prohaska, was that their edges are normally parallel in certain regions. This parallelism seems to follow from season to season as well. The pattern is repeated in Alberta with the directional tendencies being from southwest to northeast near Olds and further north, and northwest to southeast in the southern part of the province. The whole system fluctuates north-south from year to year. As a result, a large part of the central and southern portions of the province has reported hail at least once during the ten years. However, the directional tendencies remain relatively constant and some locations receive a great deal more hail than others. The study of the distribution of hail for Alberta as conducted here will deal mainly with the local physiography of the areas receiving the highest incidence of hail. The tendencies of the "hail roads" will also be considered insofar as they point out local differences within the area.

CHAPTER II. STATISTICAL COVERAGE OF THE AREA

It is difficult to obtain much information on the location of all hailstorms within the province. As hail is a local phenomenon it is not possible to turn to the weather records for information. The records of hail at the meteorological offices provide scanty or no information on most of the hailstorms which have occurred throughout the province. Therefore, the hail claim reports of the insurance companies are the chief source of information as they provide the most complete story over the ten-year period within the area. The data from the Alberta Hail Studies Project provide excellent coverage for their area for the last five years and supplement the former data admirably.

Hail Reporting Systems

In order to understand fully the data compiled from the various sources it is necessary to look briefly at the manner in which the information is collected initially.

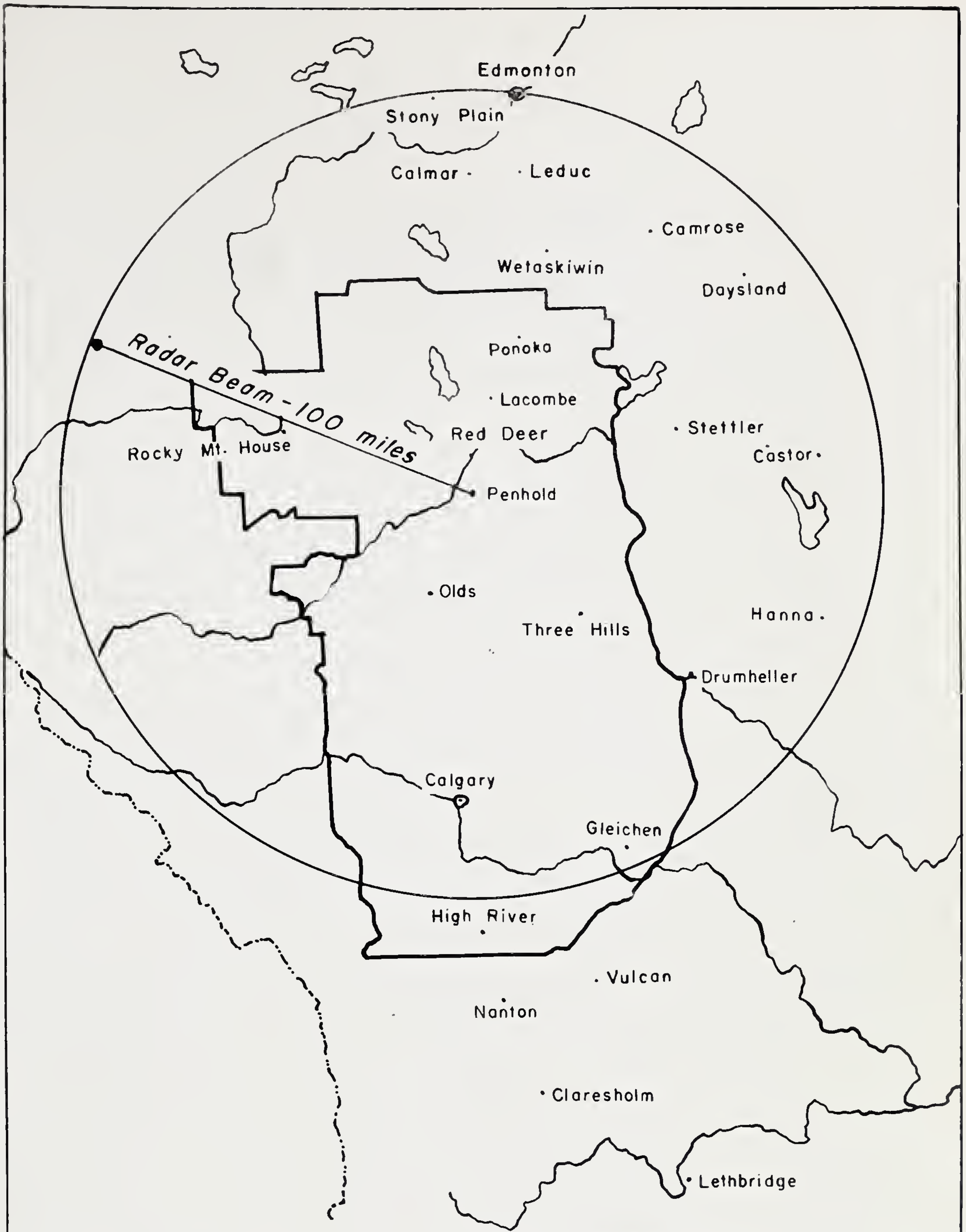
(a) Insurance Companies

When the insurance company writes a policy for hail insurance it is handled from two points of view.

The first of these is the name of the farmer or person who is taking out the insurance. The second and more important aspect for the purpose of this study, is its treatment by location giving the legal description. When a claim for crop loss is submitted to the insurance company, a card is made out to cover the claim based on its location in the grid system. The degree of loss, number of acres involved and crop affected are all noted. The date of the storm is also recorded. If more than one claim is made for a section in any one year the cards are arranged in a group first according to the section involved and secondly by the date on which the hail occurred. When processing these cards, only claims falling on different dates for any one section were tabulated. The following example will serve to illustrate why this procedure was considered necessary. If separate farmers owned one quarter section each and a severe hailstorm occurred in mid-July hitting the entire section four separate claims would be filed. Therefore, four cards would appear in the card file but the hail had, in fact, occurred only once. [1]

---

1. The smallest unit used for this study is the section. It was not possible to obtain data for the quarter sections throughout so the analysis could not be completed on that basis.



ALBERTA

HAIL REPORTING AREA, 1957–1959.

(HAIL STUDIES PROJECT)

Adapted from Douglas & Hitschfeld, "Study of Alberta Hailstorms, 1957", May, 1958, p. 2.

SCALE

0 10 20 30 40 50

MAP 1

established in 1957 as the hail reporting area for the Alberta Hail Studies Project was used for 1958 and 1959 as well. The boundaries were expanded again in 1960 thus providing information for an even larger area.

The boundaries for the project area were drawn along those of the political subdivisions, such as Municipal Districts and Counties, wherever possible. All but the extreme southern portions of the area were under the surveillance of the project's weather radar at Penhold. This provided a significant amount of additional information. [3]

The density of population varies within this area and, therefore, the numbers of reports will vary accordingly. This was not, however, taken into account when the project was defined. The density is high in the eastern half with almost 100% of the land in use. In the foothills the population density is quite low for the farms are widely scattered. The "farms become increasingly scattered as one goes west beyond about twenty miles from Penhold. Exceptions occur where major highways extend west to and beyond

---

3. See map 1 for an outline of the area used for the 1957-59 studies.

Rocky Mountain House, and further south at Caroline and Sundre, but even along these the likelihood of reasonable coverage becomes negligible within about forty miles. Thus there is a severe limitation to the distance westward from which hail reports may be expected. Since many storms move into the project area from that direction, data on first hail must often be incomplete." [4]

Printed cards were distributed to residents in the project area in order to minimize the effort required to complete the hail report. "At the beginning of the season everyone was supplied with four cards, and provision was made for resupply when these were exhausted. Information requested consisted of (a) the date of the hail occurrence; (b) the location of the property on which hail was observed (specified by township, range, section and quarter); (c) the time of the onset of the hail; (d) the duration of the hail; (e) the size of the largest stones observed. It was emphasized that all hail occurrences, no matter how small and harmless the stones, were to be reported." [5] For the purpose

---

4. Ibid., p. 3.

5. Ibid., p. 4.

of this study (b) part was the most significant as the incidence of hail over the period in any one location is the basis for the analysis. However, (a) and (c) were noted in each case in order to minimize the duplication between these cards and the insurance claims. The last two sections (d) and (e) were important for the original project as the information provided would be useful to an analysis of the physics of precipitation. They were not, however, meaningful for the analysis made here. The fact that reporting of all hail regardless of its severity was stressed is particularly significant, as has been emphasized earlier.

Size of the Area

After all the data had been tabulated it was observed that the information for the northern part of the province was so scattered and incomplete that it was necessary to confine the analysis to the central and southern portions. Therefore, the northern limit of this investigation was set at 54° N latitude, which is about thirty miles north of Edmonton. With the exception of the Peace River and Fort Vermilion areas, all the agriculturally productive regions

of the province are included. This is significant for the agricultural areas are the ones suffering the greatest loss from hail.

Limitations of the Analysis

The coverage within this region varies considerably. Several of the reasons for these fluctuations and their effects will be discussed below. It must be borne in mind, however, that the major purpose of this study is to show the correct relative frequency for the various areas. Therefore, the spatial relationships are of greater importance here than are the actual number of reports for the individual sections.

(a) Insurance Data

The insurance data from the Alberta Hail Insurance Board and the Canadian Hail Underwriters' Association have three major limitations in their coverage. These must be considered in an evaluation of the final results. The first of these is a time factor. If the hail occurs early in the season, before the crop is up, or late in the season, after harvesting operations have been completed, the hail

will not be reported to the insurance company as no claim will be made. This is not so serious an omission as it might at first appear for the major period of hail occurrence corresponds roughly with the growing season and harvest, i.e. late June, July, August, and early September. The incidence of hail in May, early June, and late September is not very high in any one year. This omission with respect to the insurance data, therefore, is not significantly great. Although this limitation is the same for the full ten years, as far as the insurance claims are concerned, the last five years have data for the early and the late storms within the project area of the Hail Studies Project. The incidence of hail outside the "growing season" was found to be very light for these five years, 1956-60.

If the hail tracks do, however, move northward during the summer the hail is apt to occur earlier in the southern part of the province than in the central portion. Therefore, this omission may have some significance for the Lethbridge - Medicine Hat area. Even here, however, its effect would not be

serious for the spatial relationship is more significant than the actual total number of hailstorms. If the physiography does affect the distributional pattern there is no reason why the tracks will form a different pattern in May or June than they do later on in the summer.

The second limitation arises from the severity of the storms themselves. Light hail will escape detection as here again no claims will be filed. Very light hail will be excluded completely from the insurance data for the entire period and, therefore, is not recorded in the survey. However, the following two factors help to ameliorate the seriousness of this situation. First, there is an accurate report of the loss which is usually checked by an insurance adjuster. Secondly, if the hailstorm occurs during the growing season it is unlikely that it will be so light throughout its entire course that no damage whatsoever will be reported. The intensity and severity of hailstorms vary within each cell and also at various points along their tracks. All storms, therefore, even the lightest ones, are apt to cause some damage, somewhere along their track. The more severe ones, of course, will have a more complete coverage but the difference is more a

matter of degree than it is of kind. It may be assumed that the lighter hailstorms follow the same tracks that the more severe ones do if such tracks (or "hail roads") do, in fact, exist.

The final limitation on the insurance data is that, even with the complete records from the companies, some of the farmers may have received hail without it being reported for not all the farmers in the province carry hail insurance. In some cases the policy might not be in effect when the hail occurs and here again no claim is made. However it is estimated by the insurance companies that approximately 85% of the families in the area under consideration have carried policies with them. This coverage varies from year to year depending on the rates charged as well as the amount of hail activity the previous year. For example, there were more policies written in 1954 following a bad year (1953) than in 1957, following three comparatively light years (1954-55-56). It has just been reported [6] that 1960 was the worst year since 1953. It is

---

6. Alberta Legislature, February 23, 1961.

reasonable to assume that the number of policies written this year will again show an increase. This latter limitation on the insurance data then fluctuates from year to year and the rate of fluctuation would be difficult to determine or control.

Although the number of farmers with hail insurance varies from year to year, depending on the rates charged and often on the amount of hail which occurred the year before, it is still the most complete source of information which is available on the incidence of hail. It is possible that farmers carrying insurance would be found in most districts of the province even though high insurance rates in some sections would reduce the proportion. The overall picture would then be reasonably reliable.

(b) Data from the Alberta Hail Studies Project

The data from the Alberta Hail Studies Project have two major limitations on them. The first of these is that the area which they selected for their project area is only a portion of the area under study here. However, the basis for this study is the information obtained from the insurance companies. This remained constant throughout the entire area.

Therefore, the difference in size between the two areas does not have an adverse effect on the study as a whole. Nor does the fact that the data from the Hail Studies Project covers only a five year period hinder the analysis in any way. For the data from the Hail Studies Project adds significantly to the basic information already obtained within their area. This supplementary material is extremely valuable in that most of the worst hail areas of the province are included thereby affording a better idea of the frequency of the hail within them.

The second limitation on the data from the Hail Studies Project arises from the number of farmers reporting hail to the central office, located at the meteorological station at Penhold. The response from the farmers within the area was excellent but not quite 100% complete. There were a few people who did not submit a card for each hailstorm occurring on their property. However, the Alberta Hail Insurance Board and the Canadian Hail Underwriters' Association made their daily claim reports available to the Research Council. This helped to complete the data for the Hail Studies Project. The omissions would again be scattered, and, therefore, not have much impact on the final result.

(c) Duplication

Within the hail reporting area of the Hail Studies Project there was some duplication of data between this Project and the various insurance companies. The material was processed in such a way as to avoid duplication wherever possible. Not all the duplication could be eliminated during the processing but the effect of a small amount would be minor for it will only add to the total number of reports in a section known to receive hail. Thus the relative pattern would remain the same.

The preceeding limitations must be borne in mind when analyzing the data and considering the results. Despite these limitations it is felt that the data compiled here is as complete as it is possible to obtain for this period. The limitations are not considered to be large enough to affect the final results to a significant degree.

CHAPTER III. ANALYSIS

The following physiographic features were considered when analyzing the physiography of the areas receiving hail most frequently, i.e. three or more times in the ten-year period. (See map 2 for the frequency and distribution pattern of hail in central and southern Alberta for the years 1951-60.)

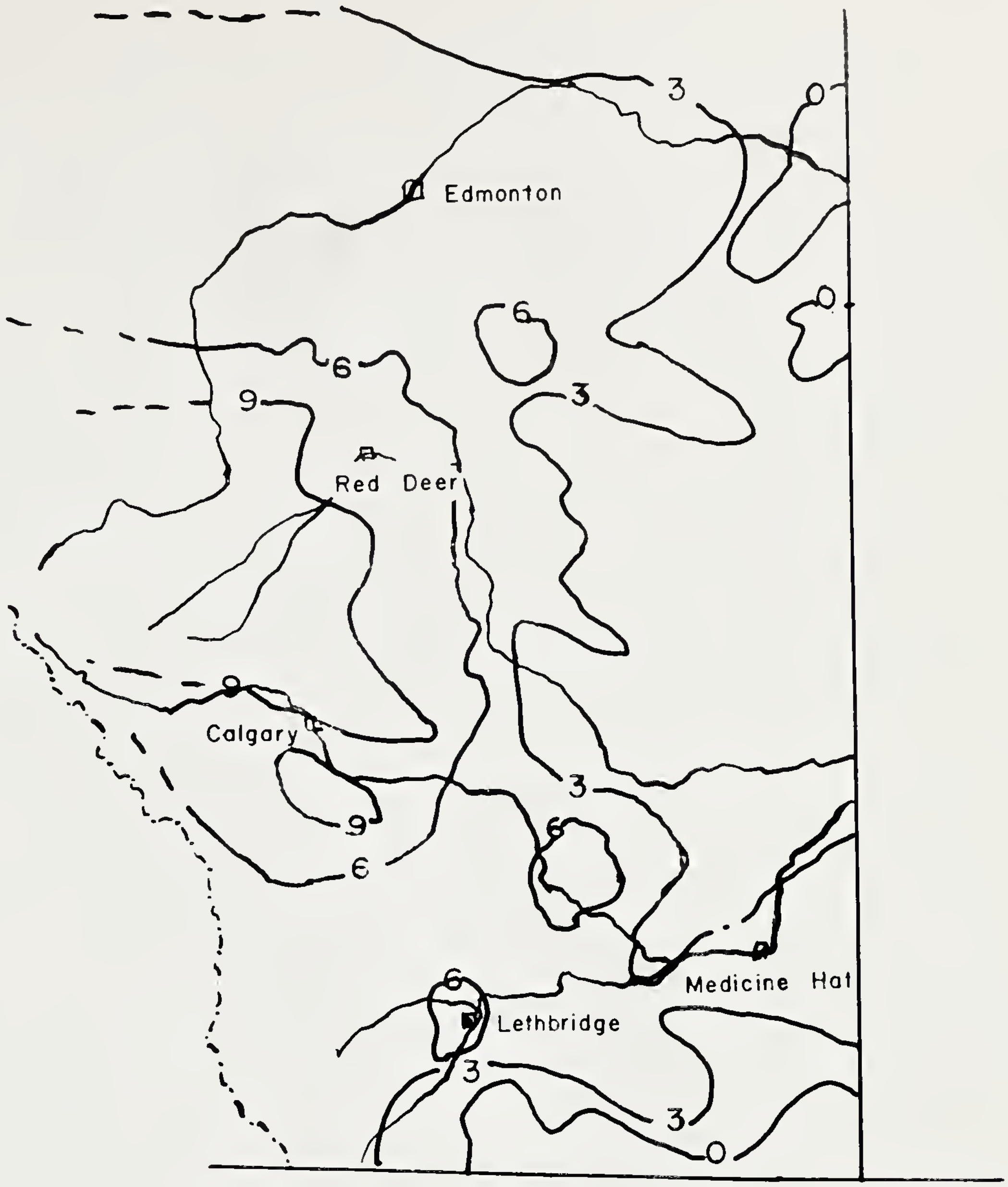
1. The local relief of the hail zones was considered. The gradients of the slopes involved were also noted.

2. The average elevation of areas having high frequency were compared with the elevation of the non-hail areas.

3. The exposure of the slope, if any, was considered to see if there is a significant difference between the windward and leeward slopes.

4. The proximity to significant water bodies, sloughs, lakes, etc., may be important so were noted in each instance.

5. The alignment and trend of valleys and hills may govern the pattern of the storm tracks. They are, therefore, an important feature of the physiography and may have bearing on the distributional pattern of hail.



ALBERTA

HAIL FREQUENCY, 1951–1960

Number of hailstorms per section

Based on township averages computed from data of the Alberta Hail Insurance Board, the Canadian Hail Underwriters' Association, and the Alberta Hail Studies Project

SCALE

70 MILES TO 1 INCH

MAP 2

Hail Areas

For ease of analysis the southern and central portions of Alberta have been divided into seven smaller areas. These areas are listed below. (see map 9, Appendix "B")

1. This area situated west of Calgary, Olds, Red Deer, and Lacombe extends into the foothills. However, the western boundary is indefinite because of the lack of data.

2. The second area lies between Calgary and Red Deer and extends eastward. It is bounded on the west by Area 1, includes Bowden, Olds, Didsbury, Carstairs, and Crossfield, and extends eastward to Big Valley, Aerial, Drumheller, and Craigmyle.

3. The third area is very irregular in shape and extends souteastward from Calgary. Its northern limit is Keoma, northeast of Calgary, extending south to Brooks and Millicent, east to Patricia, south to the Little Rolling Hills, and then northwest to Shepard, running west of Eyremore.

4. This is an extensive area with a slight southwest to northeast orientation. To the west it includes Telfordville and Bentley while on the east it extends slightly beyond Forestburg and Vegreville.

In the north central portion of this area (labelled 4x on maps 9, 16, and 17 in Appendix "B") there is a fairly extensive zone where the hail was considerably less frequent than in the adjacent sections. The physiographic differences between these sections are important.

5. A second northwest - southeast area is situated south of Calgary and includes Okotoks, Ensign, Vulcan, and Iron Springs. It extends as far east as Ronalane with its northern boundary lying north of Retlaw and Enchant and east of Mossleigh.

6. This is a large roughly triangular area in the southern portion of the province which includes Lethbridge, Medicine Hat and St. Kilda.

7. A fairly small area lies between areas 2 (to the south) and area 4 (to the north) extending from Sylvan Lake to Stettler, including Red Deer, Tees, and Lousana.

It must be noted that hail is spotty within these areas and that they are generalized for convenience in analysis. The boundaries themselves are not significant as they are not definitive and have no particular statistical value. The boundaries

have been modified from a map drawn by the Alberta Hail Insurance Board. [1] This map outlined six areas based on the experience of the Board from 1920 to 1956. These six areas are those within the province which the Board recognized as having the highest incidence of hail. It is within these areas that the insurance premiums covering hail are highest. In order to include all the patches of hail with a frequency of three or greater for the ten-year period, 1951-60, some of the boundaries of the original six areas were modified and a seventh area was added. [2] The numbering of the areas follows the system employed by the Alberta Hail Insurance Board in drawing their map. [3]

Upon analyzing the physiographic features of the hail zones within each of the areas, [4]

----

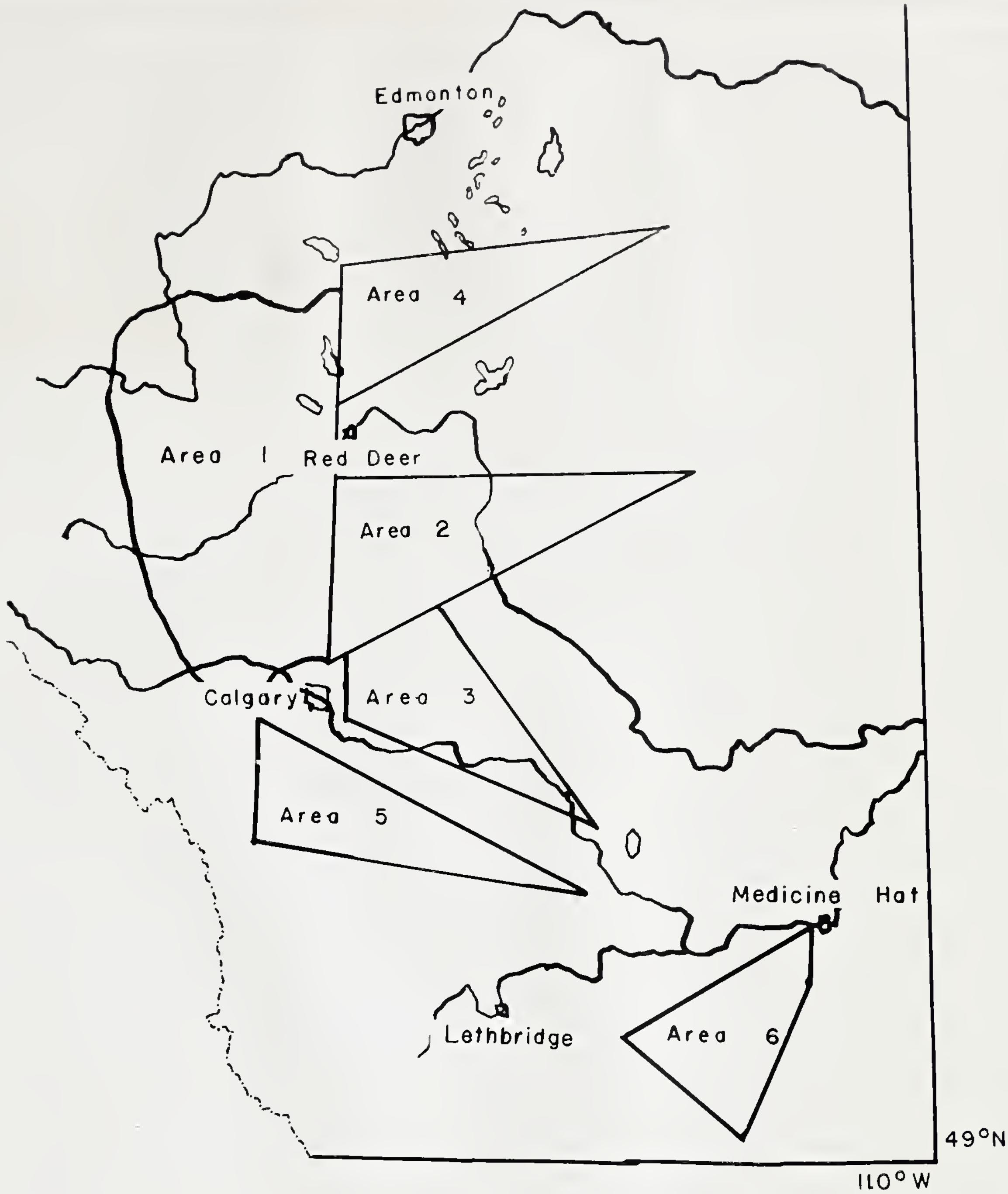
1. Thompson, 1956, p. 4. See map 3.

2. See map 9 in Appendix "B"

3. See Appendix "B" for detailed information on the physiographic features of the hail zones within these seven areas.

4. In order to study the physiography of all the hail areas within the limits of this investigation, the physiographic maps drawn by the Department of Mines and Technical Surveys, Ottawa, were used. Where possible

continued - - - - -



ALBERTA

HAIL AREAS

Based on the insurance claims of the

Alberta Hail Insurance Board (1920 – 1956)

SCALE

64 MILES TO 1 INCH

MAP 3

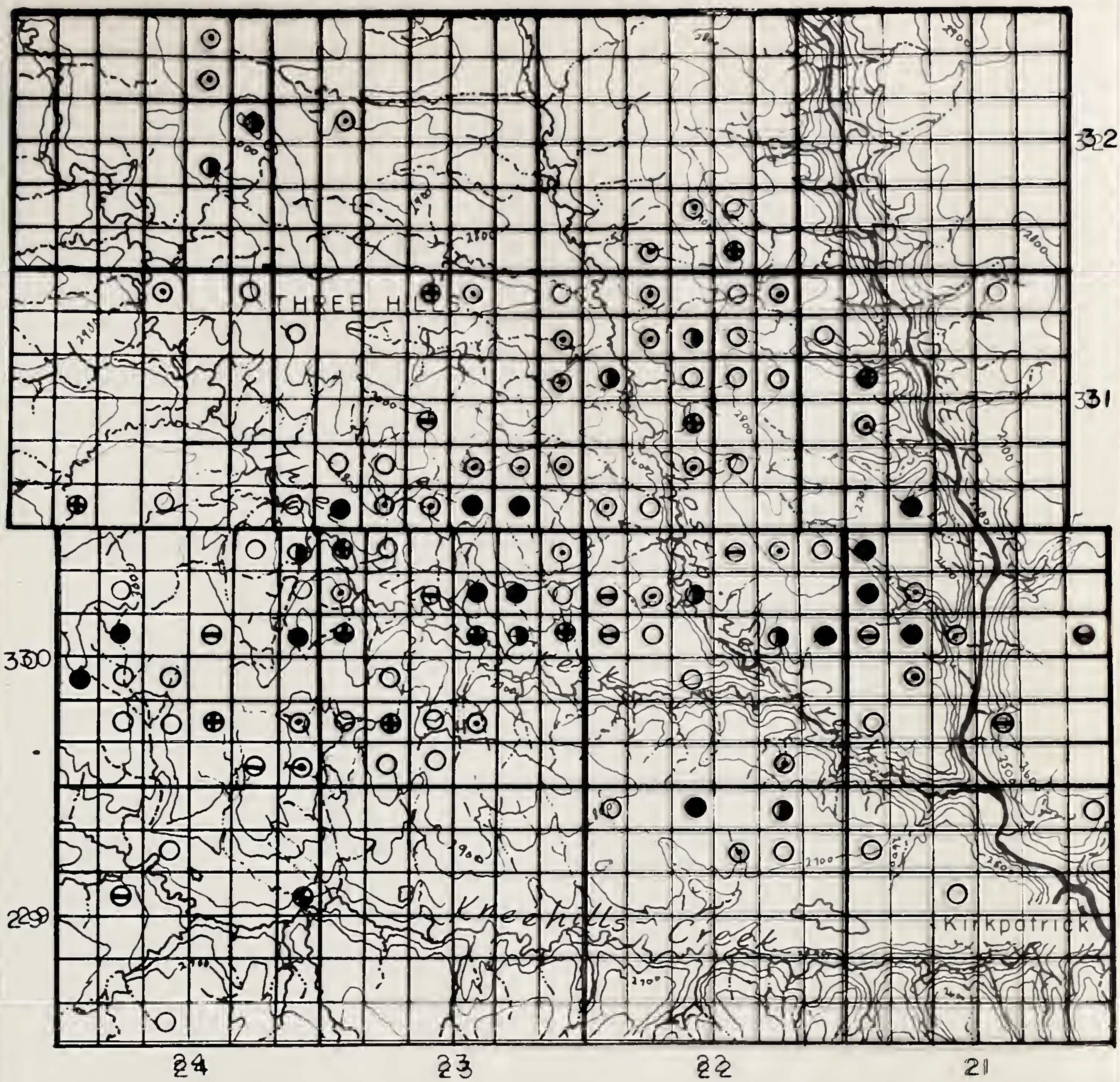
it becomes apparent that many of them have similar features. Almost all the subdivisions have these same common characteristics although variations in degree are evident from one zone to another. The sections showing an absence of hail appear to have some characteristics which differ in kind from those common to the hail zones.

Pilot Study

A representative area was chosen for detailed analysis here. The physiography of this area may be compared with the physiographic features found in the other subdivisions. (See Appendices "B" and "C".) The area is approximately 24 miles square, containing sixteen townships. (See map 4.) Three Hills is the principal town within this block which extends west from range 21 to range 24, and north from township 29 to township 32. (See map 5.) The area chosen extends beyond the "hail pocket" to include some sections which have a low frequency

---

(footnote 4 continued from page 32)
the series on the scale 1:50,000, with a twenty-five foot contour interval, was examined. As the coverage was not complete with these sheets the 1:250,000 series, with a hundred foot contour interval, was used to supplement them.



ALBERTA (HAIL ZONE – 2C)
ALBERTA (HAIL ZONE – 2 C)

HAIL FREQUENCY, 1951 – 1960

PHYSICAL

LEGEND

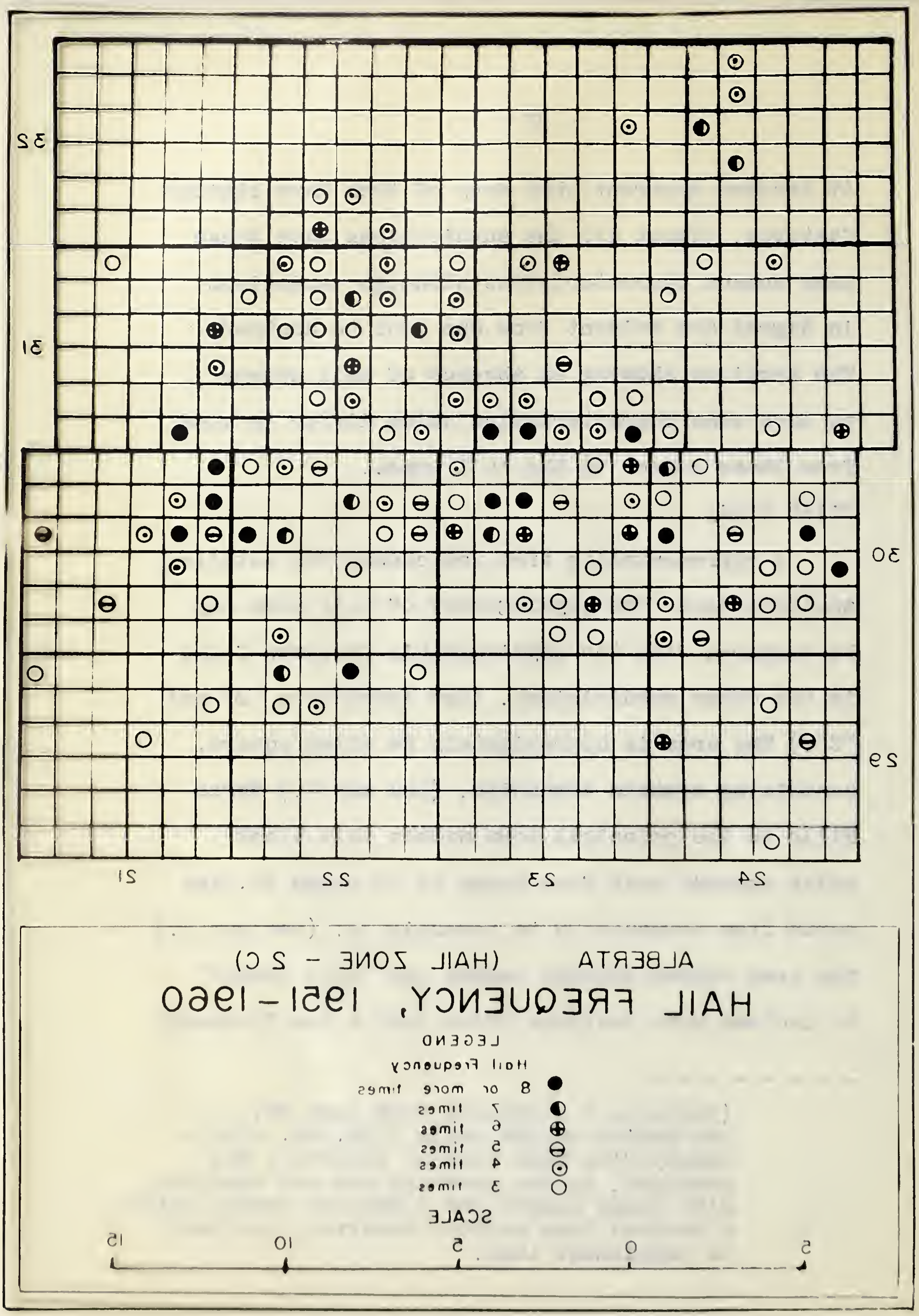
Hail Frequency

- 8 or more times
- 7 times
- 6 times
- 5 times
- 4 times
- 3 times

(Contour Interval 100 feet)

SCALE
SCALE

5 0 5 10 15


32
31
30
29
21
22
23
24
ALBERTA (HAIL ZONE - 2 C)
HAIL FREQUENCY, 1951-1960
LEGEND
Hail Frequency
8 or more times
7 times
6 times
5 times
4 times
3 times
SCALE
5
0
5
10
15

ALBERTA (HAIL ZONE - 2C)

PHYSICAL

(Contour Interval 100 feet)

SCALE

5 0 5 10 15

of hail for the ten-year period. As can be seen from map 4, the concentration of hail covers most of the block, but there are also some sections which did not receive any hail.

Most of the area experiences a fairly high incidence of hail. This "hail zone" is one of the largest of any found within the total area under study. (See map 12 and Appendix "B") The surface of the area is very irregular as it forms part of an extensive ground moraine lying to the northeast of Calgary. The concentration of hail is fairly large in ranges 21 to 24, townships 30 and 31, with almost all sections reporting damaging hail three or more times during the period. There are as many as twelve reports for some of the individual sections, e.g. range 24, township 30, section 18, and well over half the sections have more than three.

The local relief is about 750 feet for the area as a whole, ranging from 2274 feet above sea level at Kirkpatrick to over 3000 feet at the crests of the ridges. (See map 5 for the major physical features of the area.) The Red Deer River has eroded a fairly steep valley in the eastern range (21). It flows almost north-south in the southern townships while in

the northern townships it follows a north-northwest to south-southeast alignment. Further west, the Ghostpine and Threehills Creeks flow in a northwest-southeast direction before joining the Red Deer River about five miles northwest of Kirkpatrick. The interfluves between the river and these two tributaries are fairly high and likewise have a northwest-southeast alignment. [5] The fact that these three streams almost parallel each other is the most striking physiographic feature of the area. Kneehills Creek flows from the west to the east through township 29 before joining the Red Deer River about three miles downstream from the junction with the other creeks. The interfluve between Kneehills Creek and Ghostpine and Threehills Creeks to the north, follows an east-west alignment. (See map 5.) The only lake in the area, Beveridge Lake, lies immediately north of Kneehills Creek about five miles from the eastern margin of this area. There is a dearth of hail reports around the lake.

----

5. This alignment, northwest-southeast, is a very common feature in this area for the major spillway channels and many of the recessional moraines.

To the south of Kneehills Creek only two sections reported hail. In some places the slopes are too steep for cultivation. Therefore, no claims would be made to the insurance companies in the event that hail occurred on them. However, this area was within the area covered by the Alberta Hail Studies Project so there are fairly complete data on all the hailstorms of the area during the past five years. Along the south bank of Kneehills Creek there are several places where the land is under cultivation. These have not received any hail, except for two sections in the western range (24).

Along the Red Deer River there is a fairly high frequency of hail. However, hail is more widespread on the western than on the eastern bank. The banks next to the river are too steep for cultivation so the lack of hail is probably more a reflection of this than it is of an actual absence of hail.

The southern portion of the interfluve between the Red Deer River and Ghostpine Creek shows a relatively high frequency of hail with most of the sections showing hail three or more times from 1951 to 1960. Almost all the hail occurred on the gentle slopes below the 2900 foot level both in the northern

(32) and central (31) townships. The hail occurred on both sides of the interfluve.

The sections to the west have a western aspect while those to the east have an eastern aspect. The hail frequency tends to be higher to the east and south than to the west. The general slope of the land is to the south-southeast. The hailstorms in this area are frequently from the northwest. They follow along the river and creek valleys, bringing hail to both banks. This may be seen by the relatively equal distribution of hail on both the east and west banks of Ghostpine Creek.

The interfluve between Ghostpine and Threehills Creek again shows a greater concentration at the southern tip at the confluence of the two creeks. As a result, when considering micro-relief, there does not seem to be any slope which is free from hail. However, when looking at the broader scale the hail is seen to be concentrated on the southeastern portion of the interfluve.

There was a relatively high frequency of hail between Threehills Creek and Kneehills Creek (ranges 23 and 24, township 30) with most of the hail on

the slopes with a northeastern exposure. These sections probably receive hail most often when the storm track comes from the northwest and follows the Threehills Creek valley. The hail in range 24, township 30 is on a gentle slope with a southeastern exposure. The northwestern corner of the township with higher elevation than the remaining sections has a lower frequency of hail as well. Although the individual storms will go over the hills at times, they seem to be more frequent on the sides of the hills and in the valleys, especially if the valley alignment coincides with that of the storm track pattern for the area.

The northwest and north central sections of the area as a whole seem to have a lower hail frequency than the rest of the block. The maximum elevation occurs here along the crest of ridges or interfluves which are prominent features within these sections.

The valleys of the Red Deer River and Ghostpine and Threehills Creeks as well as most of the interfluves between them receive much hail. It is important to note that the upper limits of the interfluves are relatively free from hail. A striking

example of this may be seen in the lack of hail above the 3000 foot contour line two miles east of the town of Three Hills (range 23, township 32, sections 6 and 7). This is the upper portion of the interfluve between Threehills Creek and Ghostpine Creek. There are two separate farms on these sections but neither reported hail during the period.

Although the "hail roads" follow a northwest to southeast alignment, there are certain physical features along them which seem to receive hail more frequently than others. Hail appears to occur more frequently on broad flat areas than elsewhere. The gradient is fairly gentle in almost all the areas where hail has been reported. This may be related to the fact that these are the sections which are most easily cultivated rather than to the actual absence of hail on steep slopes. Another apparent trend is that hail occurs more frequently on the sides of the hills than it does on the tops of the same hills.

As there is only one lake in this area no conclusions on the effect of lakes can be inferred from this area alone. There are no reports in the

sections immediately around the lake and this pattern reappears fairly consistently in the other areas where numerous lakes are present. For example, area 4x (which contains many lakes) has had almost no hail during this period while the rest of area 4 around it shows a relatively high incidence. If the proximity of lakes and other large water bodies has a restrictive rather than conducive effect on hail incidence it may be because of the stabilizing effects which the cool water has on atmospheric conditions.

Within area 2 itself, elevations are lower to the east than to the west. The local relief for the subdivions reporting a high incidence of hail was relatively small, averaging around 300 feet. Most of the zones with a relatively high hail frequency had a northeastern, eastern, or southeastern aspect. However, slopes with a northwestern, western, or southwestern aspect received hail, particularly if they formed the eastern side of a valley where hail was fairly frequent. The majority of the storm tracks followed valleys which were aligned roughly in a northwest to southeast fashion.

The distributional pattern of the hail and the hail tracks in this area show several distinctive characteristics. Most of these appear consistently in all the other areas as well. However, because this is one of the areas with the highest frequency, these characteristics are particularly significant here.

As the coverage for this area is as complete as possible, the trends and idiosyncracies of hail observed within it may be regarded as reliable clues to the overall relationship between physiography and hail distribution.

Five characteristics which appear to be common to most of the hail zones within area 2 are listed below.

1. The slopes showing the greatest frequency of hail are gentle. The broad flat areas often received a higher frequency of hail than steeper slopes in the immediate vicinity. This may be related, in part, to the land use pattern of the area but it is also directly related to the alignment of the storm tracks. The storm tracks themselves appear to favour valleys and broad flat areas if they are aligned in the same direction as the tracks.

2. The tops of the interfluves and ridges generally show a lower frequency than slopes of the same hills or ridges. In many cases the highest hail frequency in a hail zone is found very near the top of the hill. No generalizations on this are possible for the sections having hail most frequently may be anywhere on the hillside or on the valley floor itself. Where hail is found on the crests of the ridges the frequency is generally lower than the average for that area.

3. Within area 2 most of the slopes receiving hail were facing the northeast, east, or southeast. However, hail fell on slopes with other aspects but this was generally in association with a valley which appeared to be aligned directly with the storm tracks for the area.

4. The areas immediately around lakes or other large bodies of water tend to be free from hail.

5. The areas of high hail frequency often follow broad valleys having a northwest to southeast alignment.

The five characteristics detected in zone 2c were used as a basis for comparison with the details

of the physiography for the remainder of area 2 as well as the other six areas. Appendix "B" contains a detailed analysis of all the hail zones within these areas. Maps 10, 12, 14, 16, 19, 20, and 22 show the hail frequency for the individual areas while maps 11, 13, 15, 17, 19, 21, and 23 show the major physical features associated with the hail zones. The information in this appendix was compared with the hypotheses presented above and this information is contained in Appendix "C" in tabular form. A summary of this table follows dealing briefly with each one of the hypotheses in turn.

Slopes (See Appendix "C" Column I)

A common characteristic of all the subdivisions analyzed was that the slope gradients tended to be gentle even though some of the surfaces were very irregular. In one case (area 4b) the hail was greater on the sections where the gradient had increased from five feet per mile to twenty-five feet per mile. Hail appears to concentrate more often on flat or gently sloping land than on the steeper slopes.

Actually, gently sloping land seems to be more susceptible to hail occurrence than does almost level land. It is difficult to compare the hail incidence on gentle slopes with that on steep slopes for the information on the steeper slopes varies inversely with the gradient. This is due, in large part, to the fact that the steeper slopes are increasingly more difficult to farm. Therefore, there are few reports of hail on these slopes. This, of course, is one of the main reasons for the lack of information within area 1. The eastern limits of the foothills is within area 1 and the population is relatively sparse. Hail does occur on gentle slopes, especially if the land is relatively flat, but this factor *per se* does not appear to be a contributing agency to the occurrence of hail.

Crest of Ridges (See Appendix "C" Column II)

One of the most significant characteristics of the hail distributional pattern is the relatively lower frequency of hail on the crests of ridges or hills. This feature is consistent throughout all the areas studied. In some areas where there are no distinctive hills or ridges, such as areas 2f and 3d, the hail shows a greater concentration in

the broad flat depressions within the area. In a few cases, such as areas 6i and 7h a ridge or rise occurs within the pocket of hail concentration. A break in the distributional pattern of hail occurs, coinciding with the top of the slightly elevated areas. [6]

No pattern was apparent with respect to the relative position on the slopes which received the greater incidence of hail. In some cases the hail was most severe just below the crest of the ridge, while in others it was half way down the slope or near the bottom. In several instances, this feature was striking for the hail incidence would be high on the upper portions of the slopes just below the crests and would decrease as the bottom was approached. Examples of this pattern were observed in areas 2c, 2a, 3a, and 7c but were not very widespread. Isolated hills like "The Nose" north of Calgary and the hill northwest of Bowden (area 2h) were free from hail.

---

6. See map 20 for area 6 and 22 for area 7 and also notes on these two zones in Appendix "B".

Slope Aspect (See Table I Column III Appendix "C")

The majority of the slopes in area 2c showing a concentration of hail had a northeastern, eastern, or southeastern aspect. This pattern is maintained throughout the entire area although slopes with other aspects are not free from hail. Rather they do not appear to have hail so frequently as those slopes with eastern aspects. The alignment of the valleys and storm tracks seems to be an important factor in the frequency pattern. When both sides of a valley, as well as the valley floor, show a fairly high hail frequency it is generally true that one side will show a higher frequency than the other. In most cases the sides with a north-western, western, or southwestern exposure have a lower relative frequency than the opposite banks. However, a great deal depends on the alignment of the valley itself and even more on the storm track pattern for the area. If the storm track coincides with the valley the above appears consistently. If the storm track and valley alignment are at right angles to each other the side receiving the hail first usually shows a higher frequency than the opposite side.

The storm tracks appear to have definite and distinct alignments in the northern and southern portions of the area under study. [7] The central area between Calgary and Red Deer is not so definite as it receives storms following either pattern as well as a west to east alignment, uncommon to the other areas. The storm tracks in the southern part of the province south of Calgary generally follow a northwest to southeast alignment. North of this between Calgary and Olds the storm tracks rotate first to a west-east direction and then to a southwest-northeast direction north of Red Deer. Most of the slopes receiving hail tend to have a southeastern, eastern, or northeastern aspect depending on their relative location. As they are on the lee side of the ridges, hills or valleys this indicates that they are affected by the orientation of the tracks themselves.

Presence of Lakes (See Table I Column IV)

Within the subdivisions showing hail there are very few instances where large bodies of water are present. In area 6 many of the subdivisions

----

7. See maps 6, 7, and 8.

(a, b, d, e, f, g and i) show numerous small lakes or sloughs, but all are of an intermittent nature. In the other subdivisions where large lakes are present or nearby (e.g. area 4j and 7g - Gull Lake, and area 7h - Sylvan Lake and Cygnet Lake) the hail tends to be away from the margins of these lakes. For example, there was almost no hail within a six mile radius of Gull Lake. A similar pattern is found to the south, west, and north of Sylvan Lake and north, east, and south of Cygnet Lake. A storm track, however, which follows a southwest to northeast orientation passes between these two lakes. As a result hail is found nearer their margins on the eastern side of Sylvan Lake and the western side of Cygnet Lake. In area 4x numerous permanent lakes occur. This area was analyzed for its lack of hail so the major physiographic features are important, especially if they are different in kind from those features present in the hail areas. The major difference here is the presence of the lakes on the pitted outwash plain. It appears, therefore, that the effect of large permanent lakes on the distributional

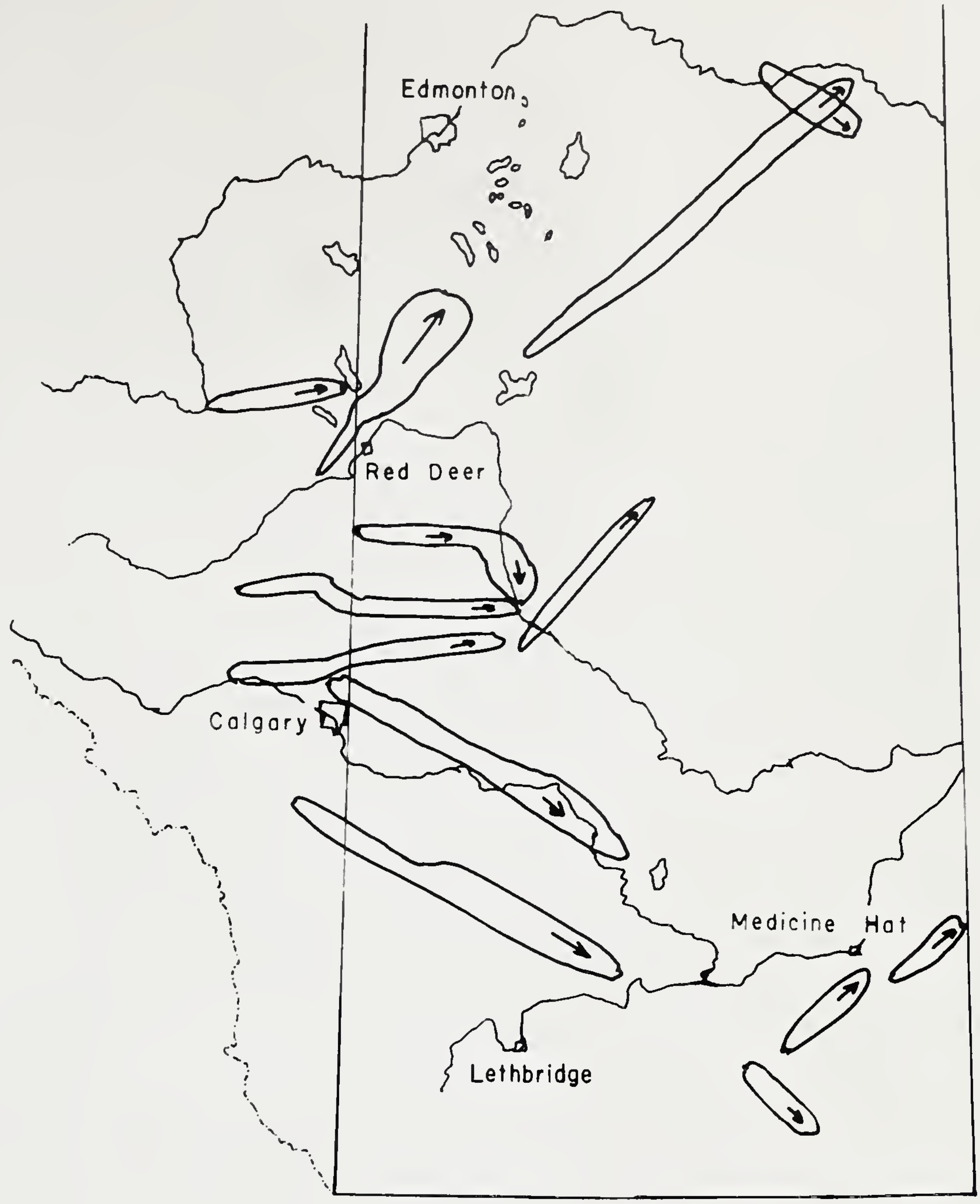
pattern of hail is a negative one rather than a positive one, for hail frequency is reduced in areas where they are located.

Trend of Valleys and Ridges (See Table I Column V)

In area 2c the trend of the valleys was generally northwest-southeast. However, as seen with respect to slope, the alignment of the valleys receiving a relatively high incidence of hail changes with a change in latitude. There is a direct correlation between the valley alignment and storm track pattern and when the two coincide the incidence of hail becomes relatively high. The hail is most frequent on bread flat valleys, slopes with gentle gradients , and in basins or depressions. In some cases the storm tracks, hail pocket, and ridge line are parallel to each other. In other instances, such as area 5b, (See Appendix "B") the storm track and hail pocket are perpendicular to the ridge line.

Storm Tracks

The tracks of the major storms for the years 1953, 1955 and 1960 point out the north-south



ALBERTA

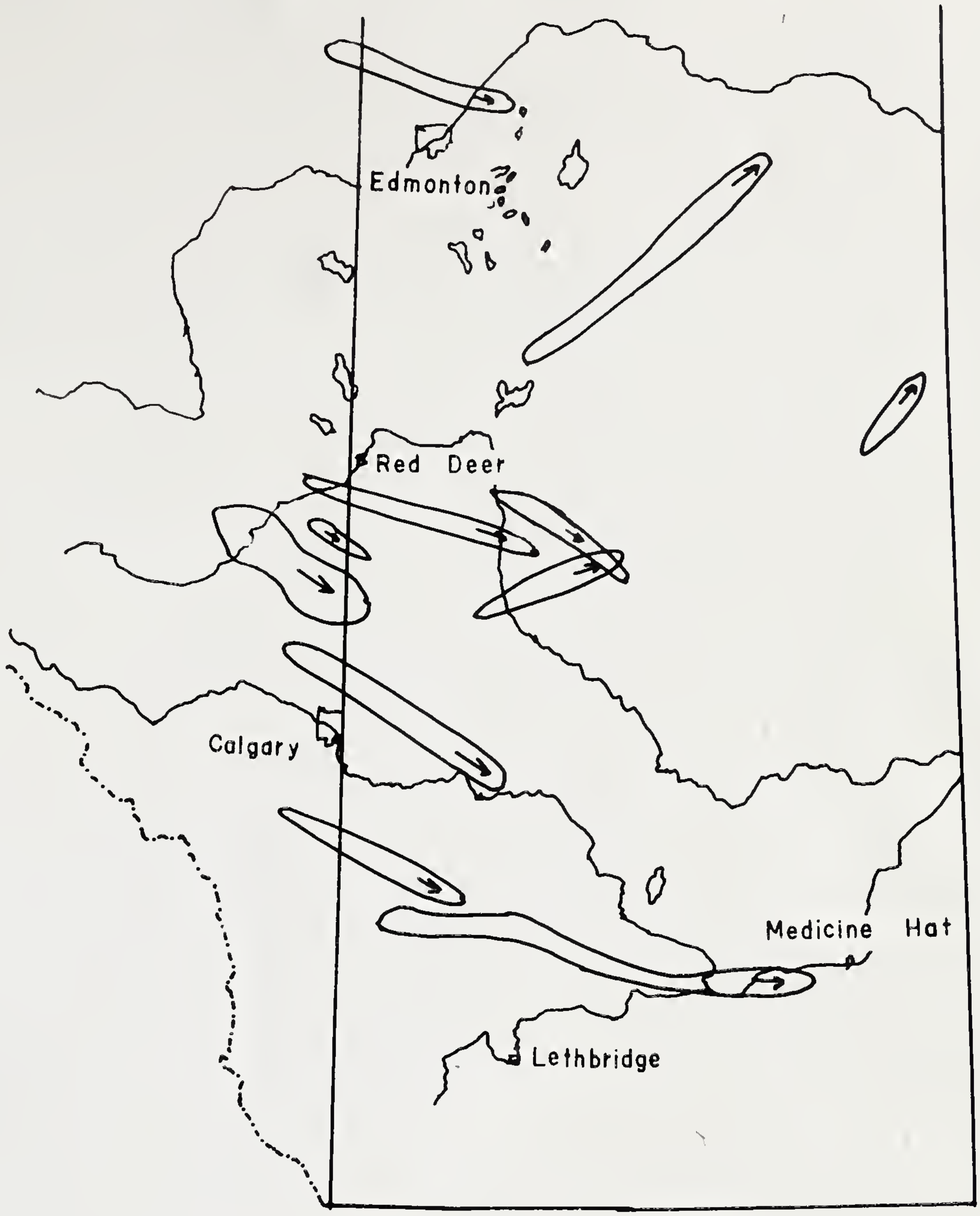
MAJOR HAILSTORM TRACKS, 1953

→DIRECTION OF MOVEMENT OF STORM

Data obtained from the Alberta Hail Insurance Board

SCALE

64 MILES TO 1 INCH



ALBERTA

MAJOR HAILSTORM TRACKS, 1955

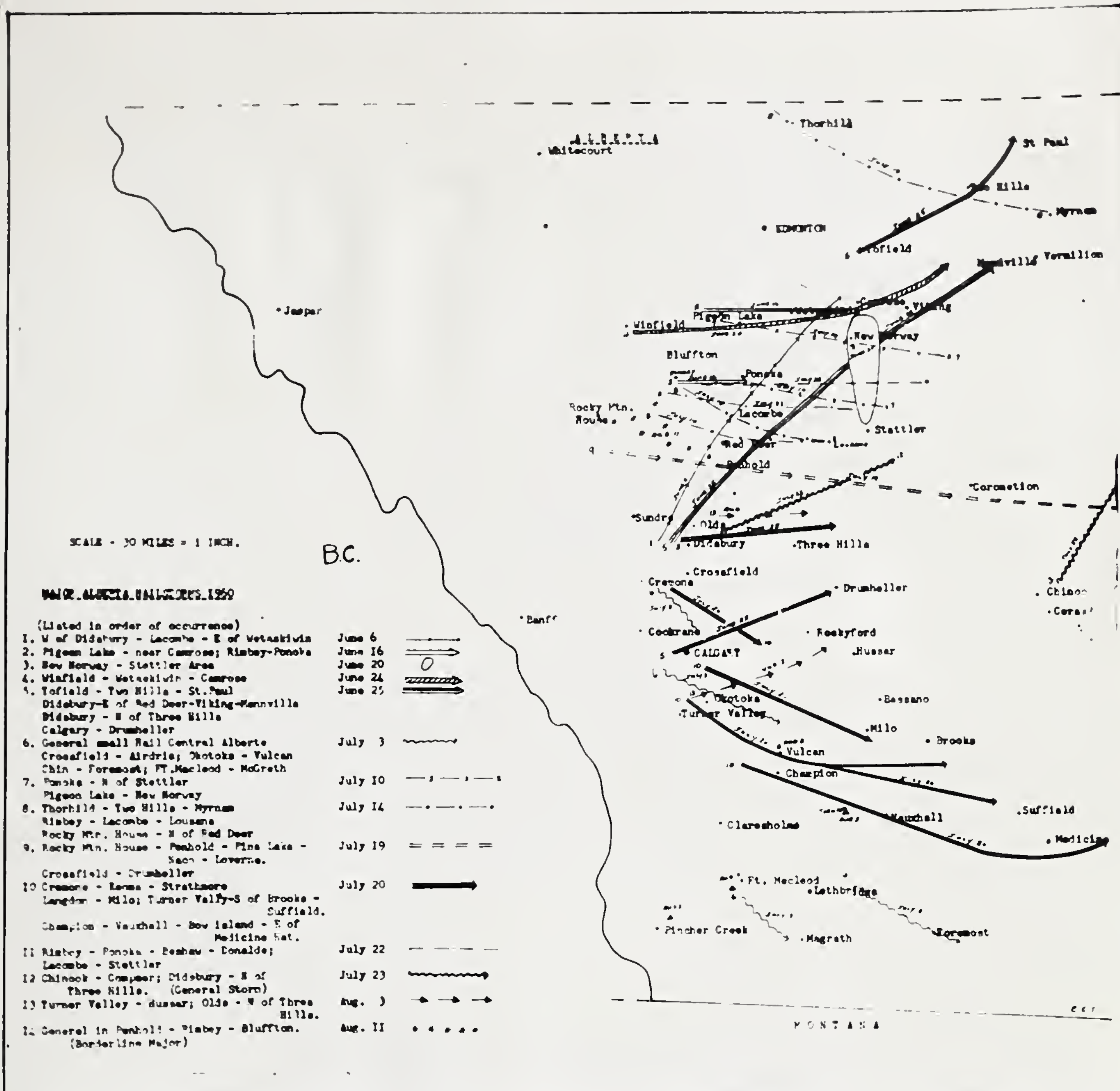
⟶ DIRECTION OF MOVEMENT OF STORM

Data obtained from the Alberta Hail Insurance Board

SCALE

64 MILES TO 1 INCH

MAP 7



ALBERTA

MAJOR HAILSTORM TRACKS, 1960

With the kind permission of C. E. Thompson

fluctuations [8] in the whole system which may occur from year to year. (See maps 6, 7, and 8) They also serve to show how the general pattern is maintained with the individual storms going to the southeast in the southern portion of the system, to the east in the central portion, and finally to the northeast. A few exceptions may be noted but this pattern tends to be consistent from one year to the next. It is relevant here to note that these tracks are included within the areas mapped and, in fact, the complete picture presented by the tracks for the ten years formed the basis on which the boundaries for the seven areas were drawn.

----

8. 1953 and 1960 were selected for analysis with respect to the distributional pattern of the storm tracks because the hail was particularly severe during these summers. Although the hail activity was not so great for the summer of 1955, it was included because the tracks were further north than in 1953 or 1960.

CHAPTER IV. CONCLUSION.

The object of this study has been to determine whether or not the hail distributional patterns in central and southern Alberta bear any direct relationship to the physiography of the area.

In most of the areas having a relatively high hail frequency the following four physiographic features are present. There was no apparent pattern or combination for these characteristics but the variation was largely one of degree.

The first characteristic is that hail appears to occur more frequently on the leeward slopes of the ridges and hills. The actual slope aspect varies within the area but this is largely dependent upon the alignment of the storm tracks for the individual sections considered. Hail does occur on the windward slopes as well but its average frequency is much lower than to the lee. When it is on the windward slopes it is usually in conjunction with a fairly large "hail pocket" or zone such as along a valley, and often the average frequency for this slope is below the average for the hail zone as a whole.

The position with respect to the alignment of the storm tracks seems to be a determining factor in these instances.

Secondly, in the sections immediately around large permanent lakes the hail is less severe and less frequent than the average for the immediate area. This may indicate that these lakes tend to restrict rather than promote hail.

Thirdly, broad flat areas and valleys very often have a higher average frequency of hail than the areas with fairly steep slopes. The gentle slopes on the hillsides generally have a higher average hail frequency than the steeper slopes. In many cases the steepest slopes in the individual areas show a dearth of hail. This may be the result of the land use pattern in the area. If the gradient is steep enough to inhibit cultivation it is unlikely that any hail will be reported.

Finally, the frequency of hail is very much smaller on the tops of the hills or crests of the ridges than it is on the lee slopes of these same hills or ridges. The portion of the slope showing

the highest frequency varied considerably. In some cases it was near the top, sometimes half-way down and in many instances at the bottom. The valley floor itself often had the highest average frequency. The hail seemed to be more related to the slope gradients involved rather than to the relative position on the hill. The gentler slopes generally had a higher average.

Two other features have become apparent which may indicate that there is a definite source area or "breeding" area for almost all of the hailstorms which occur in Alberta. The first of these is that the hail incidence tends to be higher in the western sections of the area studied than in the eastern sections. Some of the sections in the foothills area and on its eastern margins have recorded hail twenty times or more in the ten-year period. The storms tend to move eastward from that area centred along the eastern flanks of the front range between Kananaskis and Brazeau. (See maps 6 - 8) In the southern part of the province the storms tend to go southeastward while in the northern portion of the area the tracks are

to the northeast. In the central portion of the system they may be aligned west-east or they may move either to the northeast or southeast. If the foothills area is, in fact, a "breeding ground" for hail a study of the physiographic features of that particular area might reveal some very valuable information with respect to the other factors which are present in the initial stages in the development of hailstorms.

BIBLIOGRAPHY

1. Battan, Louis J., 1959. Radar Meteorology. Chicago, University of Chicago Press.

2. Beckwith, W. Boynton, 1960. "Analysis of Hailstorms in the Denver Network, 1949-1958. " (Helmut Weickmenn, ed., Physics of Precipitation). Baltimore, Waverly Press, pp. 348-353.

3. Byers, Horace Robert, 1959. General Meteorology. 3rd. ed. Toronto, McGraw-Hill Publishing Co. Ltd.

4. Donaldson, R. J., et al., 1960. "Some Behaviour Patterns of New England Hailstorms." (Helmut Weickmenn, ed., Physics of Precipitation). Baltimore, Waverly Press, pp. 354-368.

5. Douglas, R. H., 1959. "Alberta Hail, 1958 and Related Studies, Parts I and II", McGill University, "Stormy Weather" Research Group. Scientific Report MW-30.

6. Douglas, R. H., Hitschfeld, Walter, 1958. "Studies of Alberta Hailstorms 1957", McGill University, "Stormy Weather" Research Group. Scientific Report MW-27.

7. Douglas, R. H., & Hitschfeld, W., 1959. "Patterns of Hailstorms in Alberta." Quart. Journal Roy. Met. Soc. 85, 105-119.

8. Feteris, P. J., 1955. "£ 330,000 Hail Damage in Fifteen Minutes, Analysis of a Devastating Hailstorm." Weather. Roy. Met. Soc., Vol. X, pp. 223-232.

9. Feteris, P. J., 1956. "The Need for Detailed Information on the Characteristics of Hailstones." Weather. Roy. Met. Soc., Vol. XI, pp. 107-109.

10. Flora, Snowden D., 1956. Hailstorms of the United States. Norman, University of Oklahoma Press.

BIBLIOGRAPHY

(Cont'd.)

11. Korven, K. M., 1960. "A Report on Surface Winds and Related Phenomena Associated with Thunderstorms Tracked by Radar at R.C.A.F. Station, Penhold, Alberta. June to August, 1959." Meteorological Service of Canada, CIR 3342, TEC 324.

12. Lemons, Hoyt, 1942. "Hail in High and Low Latitudes." Bulletin of the American Meteorological Society, Vol. 23, No.2, pp. 61-75.

13. Mason, B. J., 1957. The Physics of Clouds. Oxford, Clarendon Press.

14. Sänger, Raymund, 1960. "The Mechanism of Hail Formation." (Helmut Weickmenn, ed., Physics of Precipitation). Baltimore, Waverly Press, pp. 305-309.

15. Thompson, C. E., 1956. "The Problems of Hailstorm Forecasting in Alberta." Meteorological Service of Canada, CIR 2804, TEC 236.

16. Thompson, C. E., & Smith, D. H., 1960. "A Synoptic Study of the 1958 Hail Season in Central Alberta." Meteorological Service in Canada, CIR 3308, TEC 317.

17. Weickmenn, Helmut, 1953. "Observational Data on the Formation of Precipitation in Cumulonimbus Clouds." (Horace R. Byers, ed., Thunderstorm Electricity.) Chicago, University of Chicago Press, pp. 66-138.

APPENDIX "A"

Statistics of Hail Incidence in Alberta, 1951-60, inclusive.[1]

WEST OF THE 4th. MERIDIAN

Range 1.

T.9, S.2-3;

T.17, S.19-4; 20-3; 27-3; 30-3;

T.18, S.3-3; 4-3; 19-3;

Range 2.

T.17, S.23-3;

T.18, S.28-3; 30-3;

T.24, S.7-3; 19-3;

T.25, S.23-3; 26-4;

Range 3.

T.24, S.2-3; 3-3; 4-3; 9-3;

T.39, S.9-3; 18-3;

T.40, S.28-3; 30-3; 32-3;

Range 4.

T.12, S.22-3; 24-3; 25-3; 36-3;

T.13, S.1-3;

Range 5.

T.13, S.3-3;

Range 6.

T.12, S.19-3; 32-3;

---

1. Only those sections reporting more than 3 occurrences of hail for the 10 years are listed.

WEST OF THE 4th. MERIDIAN

Range 6.

T.34, S.34-5;

T.53, S.33-3;

T.55, S.6-3; 13-3; 32-5;

T.56, S.6-5; 7-4; 9-5;

Range 7.

T.11, S.30-3; 31-3; 32-3;

T.12, S.8-3;

T.52, S.17-3; 32-3;

T.53, S.6-3;

T.54, S.32-3;

Range 8.

T.11,S.36-3;

T.12, S.1-3;

T.40, S.35-3;

T.55, S.1-3; 2-3; 11-3; 12-3;

Range 9.

T.4, S.19-3; 30-4; 31-3;

T.5, S.4-4; 5-4; 6-4; 9-4; 16-4; 17-4;

T.8, S.30-3;

T.10, S.6-3; 7-5; 8-3; 9-3;

T.41, S12-3;

T.50, S.22-3;

T.51, S.9-3;

WEST OF THE 4th. MERIDIAN

Range 10.

T.3, S.1-3; 12-6; 14-4; 15-3; 23-4; 26-3;
S.31-3;

T.4, S.22-5; 23-3; 24-3; 25-8; 27-4; 34-5;
S.35-4; 36-3;

T.5, S.1-8; 2-3; 9-3; 15-5; 6-3; 27-5;

T.10, S.12-3; 13-3; 15-3; 16-3; 21-3; 22-3;
S.36-3;

T.17, S.30-3; 31-3;

T.40, S.20-4;

T.49, S.25-4; 26-4; 30-3; 33-3; 34-4; 36-3;

T.50, S.9-3;

Range 11.

T.3, S.25-3; 27-5; 30-3;

T.49, S.2-3;

T.50, S.2-3; 3-4; 12-3; 13-4;

Range 12.

T.3, S.34-3;

T.8, S.17-3;

T.17, S.5-3; 7-3;

T.41, S.18-3;

T.48, S.19-3; 20-3;

WEST OF THE 4th. MERIDIAN

Range 13.

T.13, S.13-4; 20-5; 21-6; 23-3; 26-5;
S.27-5; 28-3; 29-3;

T.14, S.32-3;

T.15, S.2-3; 4-3; 9-3; 10-3;

T.16, S.16-3; 18-5; 36-5;

T.17, S.4-4; 6-4; 9-5; 15-3; 17-4; 18-4;
S.19-4; 20-7; 21-10; 22-5; 23-7;
S.27-11; 28-3; 29-4; 30-6; 31-4;

T.28, S.36-3;

T.42, S.31-3;

T.43, S.11-3; 13-3;

T.48, S.13-3;

T.55, S.12-3;

T.56, S.2-3; 3-3; 10-3;

Range 14.

T.6, S.2-4; 16-3;

T.13, S.13-5; 25-3; 26-3; 27-4;

T.17, S.13-6; 24-6; 26-3; 34-3; 35-5; 36-8;

T.18, S.10-3; 11-3; 12-3; 14-4;

T.19, S.1-3; 12-4; 13-4;

T.20, S.2-3; 6-4; 11-5; 14-3;

WEST OF THE 4th. MERIDIAN

Range 14.

T.29, S.30-3;

T.36, S.21-3; 28-3; 29-3;

T.42, S.7-3; 17-3; 20-3; 28-3; 29-3;

S.30-3; 32-3; 34-3;

T.43,S.30-4;

T.47, S.19-3;

T.50, S.23-3;

T.54, S.31-3;

T.55, S.25-3;

T.58, S.18-3; 20-4; 21-4; 27-3; 28-4;

S.29-5; 30-5; 31-5; 33-6; 34-4;

T.59, S.3-3; 4-3;

Range 15.

T.6, S.1-3; 12-4;

T.8, S.18-3; 20-3; 21-3;

T.13, S.35-3;

T.14, S.1-3;

T.15, S.31-4;

T.16, S.19-3; 30-8;

T.18, S.25-3;

T.19, S.7-11; 9-3; 15-3; 16-4; 18-3;

S.29-4; 30-5; 31-5;

WEST OF THE 4th. MERIDIAN

Range 15.

T.21, S.11-3;

T.42, S.9-3; 31-3;

T.43, S.3-3; 10-4; 11-3; 12-3; 14-3; 18-3;

S.25-3; 26-3; 28-3; 29-3; 30-3; 31-3;

T.45, S.34-3;

T.46, S.18-3; 19-3; 26-3; 30-3;

T.47, S.2-3; 7-3; 12-3; 13-3; 15-3; 16-3;

S.21-3; 22-3; 23-3; 24-3; 25-3;

S.26-3; 29-3; 30-3;

T.48, S.13-3; 15-3; 16-3;

T.49, S.31-4; 32-3;

T.50, S.7-3; 9-3; 30-3;

T.53, S.11-5; 12-3; 14-4; 15-3; 22-3; 23-3;

T.54, S.17-3; 18-3; 19-5; 20-3; 29-3; 30-3;

Range 16.

T.6, S.32-4; 33-5;

T.7, S.2-3; 9-3; 11-3;

T.12, S.27-3;

T.14, S.14-3; 21-3;

T.15, S.36-3;

T.16, S.2-3; 14-4; 16-5; 17-3; 20-3;

S.21-5; 22-5; 23-3; 26-3; 27-6; 28-4;

S.29-4; 32-3; 33-6; 34-5; 35-4;

WEST OF THE 4th. MERIDIAN

Range 16.

T.17, S.3-7; 4-5; 5-5; 15-4; 17-4;
S.18-4; 19-4; 20-5; 30-4;

T.18, S.29-3; 32-3;

T.19, S.13-5;

T.34, S.26-3;

T.42, S.25-4; 28-3; 32-3; 33-3; 34-6;
S.35-4; 36-3;

T.43, S.4-4; 9-4; 12-5; 13-4; 14-3; 20-4;
S.23-3; 27-3; 31-3;

T.44, S.4-3; 5-3; 6-3; 7-3; 8-5; 9-4;
S.16-4; 17-3;

T.45, S.5-3; 18-3; 36-3;

T.46, S.8-3; 17-3; 33-3;

T.47, S.4-3; 5-3; 6-4; 7-3; 34-3; 35-3;

T.48, S.10-3; 11-3; 24-3; 34-3; 35-3;

T.49, S.21-3; 35-3;

T.50, S.3-3; 5-3; 12-5; 13-5; 29-3; 35-3;

T.51, S.1-3; 20-3; 21-3; 27-3; 28-3;

T.53, S.23-6; 24-3; 26-3;

T.54, S.24-3;

T.55, S.11-3; 21-5; 26-5; 27-4; 28-4;
S.33-4; 34-3; 35-3; 36-4;

WEST OF THE 4th. MERIDIAN

Range 17.

T.6, S.6-4; 7-5;

T.7, S.12-3;

T.12, S.5-3; 13-3; 17-3; 23-3; 24-3;
S.32-3; 36-4;

T.13, S.1-3; 8-3; 9-3; 13-4; 14-3;
S.15-3; 16-3;

T.14, S.10-3; 12-3; 13-3; 14-3; 15-3;
S.16-5; 21-5;

T.17, S.23-3; 24-3;

T.20, S.4-4; 9-4;

T.30, S.24-3;

T.31, S.31-3;

T.34, S.15-3;

T.37, S.6-3;

T.43, S.15-3; 17-3; 22-3; 29-4; 31-3;
S.32-4; 33-3;

T.44, S.1-3; 2-3; 4-3; 5-3; 6-3; 7-3;
S.8-8; 10-3; 12-4; 16-5; 17-4;
S.18-3; 21-5; 23-3; 32-3;

T.45, S.12-3;

T.46, S.18-3;

T.47, S.16-3; 26-3;

WEST OF THE 4th. MERIDIAN

Range 17.

T.49, S.35-3;

T.50, S.30-3;

T.55, S.1-3; 12-3; 31-3; 32-3; 33-4;

T.56, S.29-3;

T.60, S.12-3;

Range 18.

T.6, S.1-3; 2-5; 3-5; 8-3; 11-5; 12-5;
S.13-7; 15-3; 22-3;

T.12, S.27-4;

T.13, S.4-3; 18-4; 19-3; 22-3;

T.14, S.19-3;

T.15, S.2-3; 3-3; 8-3; 9-5; 10-5; 12-4;
S.13-4; 16-4; 18-3; 30-3;

T.16, S.3-3; 4-3; 5-5; 14-5; 16-5; 17-3;
S.23-3;

T.31, S.9-10;

T.32, S.17-3; 20-4;

T.42, S.22-4;

T.43, S.5-5; 11-3; 16-3; 25-3; 26-5;
S.33-3; 36-4;

T.44, S.2-4; 3-6; 4-7; 7-3; 9-6; 10-7;
S.11-4; 13-3; 14-5; 15-6; 16-5;
S.19-3; 20-5; 21-5; 22-3; 24-3;
S.26-7; 27-5; 28-3; 29-5; 30-4;
S.31-5; 32-8; 35-6; 36-3;

WEST OF THE 4th. MERIDIAN

Range 18.

T.45, S.2-5; 4-3; 5-4; 18-3; 30-4; 31-4;

T.46, S.2-3; 4-3; 6-3; 9-3;

T.47, S.36-3;

T.48, S.35-3;

T.53, S.4-3;

T.55, S.24-4; 26-3;

Range 19.

T.7, S.7-3; 33-4; 34-5; 35-3;

T.8, S.23-3; 24-3; 25-3;

T.12, S.9-3; 16-3; 17-3; 24-3; 35-3;

T.13, S.1-3; 19-4; 34-4; 35-3; 36-3;

T.14, S.2-4; 3-5; 11-3; 13-3; 16-3;

S.20-3; 24-3; 28-3; 33-3;

T.15, S.2-4; 3-4; 8-3; 15-3; 21-3;

S.22-3; 25-3; 36-3;

T.16, S.12-4; 22-3; 24-3; 26-3;

T.30, S.9-3; 10-4; 14-4; 15-3;

S.16-3; 17-4; 18-6; 21-5;

T.31, S.2-3; 28-3; 31-3;

T.35, S.12-3;

T.38, S.31-5;

T.39, S.9-3;

T.41, S.26-3;

T.42, S.1-3; 7-4; 16-4;

WEST OF THE 4th. MERIDIAN

Range 19.

T.43, S.3-4; 5-3; 12-3; 33-3;

T.44, S.4-3; 5-4; 6-5; 9-4; 10-6; 11-7;

S.12-5; 13-5; 14-4; 15-8; 16-4;

S.20-4; 21-4; 22-5; 23-5; 24-5;

S.26-4; 27-4; 30-5; 31-3; 33-5;

S.34-5;

T.45, S.10-4; 30-3; 35-3; 36-3;

T.46, S.26-6;

T.47, S.4-3;

T.48, S.14-3; 19-3;

T.49, S.4-3;

T.59, S.27-3; 33-3;

Range 20.

T.7, S.12-5;

T.13, S.13-3; 24-4;

T.14, S.35-3; 36-3;

T.15, S.13-3; 24-4;

T.16, S.33-3;

T.17, S.21-3; 22-3; 24-3; 25-3; 28-3;

T.24, S.35-3;

T.25, S.3-8; 10-3;

T.26, S.18-3;

T.27, S.9-3;

WEST OF THE 4th. MERIDIAN

Range 20.

T.29, S.2-3;

T.30, S.2-5; 4-4; 6-7; 9-3; 17-3; 19-4;
S.27-3; 29-3;

T.31, S.16-3; 22-3;

T.32, S.22-3;

T.35, S.23-3; 26-3;

T.41, S.1-4; 30-3;

T.42, S.5-4; 7-6;

T.43, S.28-7; 31-4; 32-8; 35-3; 36-3;

T.44, S.1-4; 2-3; 4-5; 9-3; 10-4; 11-3;
S.13-3; 14-4; 15-4; 16-3; 17-4;
S.22-6; 23-3; 24-7; 25-8; 26-3;
S.27-3; 33-3; 34-3; 35-3; 36-3;

T.45, S.1-3; 2-3;

T.46, S.11-5; 13-3; 24-3; 31-9; 32-3;

T.47, S.5-5;

T.57, S.5-3;

T.59, S.9-3; 21-3; 33-3;

Range 21.

T.8, S.2-4; 5-3; 7-4; 8-3; 16-4; 17-5;
S.20-3; 22-4;

T.18, S.20-3; 21-3; 30-4; 32-3;

T.25, S.4-3; 14-3;

T.26, S.12-4; 20-9;

WEST OF THE 4th. MERIDIAN

Range 21.

T.29, S.21-3; 30-3; 36-3;

T.30, S.7-3; 10-5; 17-4; 19-5; 20-14;

S.21-4; 24-5; 29-4; 30-8; 31-17;

T.31, S.4-10; 17-4; 20-6; 30-3; 35-3;

T.35, S.30-3;

T.38, S.9-3; 14-3; 17-6; 18-5;

T.40, S.12-3; 30-4;

T.41, S.5-4;

T.43, S.15-3;

T.44, S.2-3;

T.46, S.24-4; 26-5; 28-6; 33-3;

T.54, S.17-4; 29-3; 32-3;

T.57, S.4-4;

T.59, S.22-3; 27-3;

Range 22.

T.7, S.19-3;

T.8, S.12-4;

T.14, S.11-3; 17-3; 18-6; 19-5; 20-6;

T.16, S.8-3;

T.20, S.22-3;

T.23, S.19-3; 29-4;

T.25, S.7-4; 26-3;

T.26, S.34-4;

WEST OF THE 4th. MERIDIAN

Range 22.

T.27, S.32-3;

T.29, S.26-3; 27-4; 31-3; 33-8; 35-7;

T.30, S.2-4; 16-3; 19-5; 20-3; 23-7;
S.24-9; 27-4; 28-7; 29-4; 30-5;
S.35-4; 36-3;

T.31, S.4-3; 5-4; 7-4; 10-4; 11-3;
S.15-6; 19-4; 20-7; 22-3; 23-3;
S.24-3; 27-7; 28-4; 30-4; 31-3;
S.33-4; 35-3; 36-4;

T.32, S.2-6; 4-4; 10-4; 11-3;

T.33, S.29-5; 30-8; 32-7;

T.34, S.5-3; 6-3; 8-6; 25-4;

T.36, S.2-4; 16-4; 18-3; 20-3;

T.37, S.22-4; 31-4;

T.38, S.20-6; 29-4; 30-3; 31-3;

T.39, S.1-5;

T.41, S.1-4;

T.43, S.28-5;

T.44, S.2-3; 6-4;

T.45, S.6-3;

T.46, S.6-4; 20-3; 21-3; 33-3;

T.47, S.4-3; 7-7;

T.48, S.8-3; 9-4;

WEST OF THE 4th. MERIDIAN

Range 22.

T.52, S.33-3;

T.55, S.8-4; 17-4; 18-3; 21-3; 29-3;

T.56, S.3-3; 5-3; 8-3; 11-4;

T.60, S.27-3;

T.61, S.7-3;

Range 23.

T.6, S.29-3; 30-3; 33-3;

T.7, S.3-3; 29-3; 33-3; 34-3; 35-3;

T.15, S.14-5; 15-3; 19-3; 33-3;

T.20, S.31-3;

T.24, S.6-8

T.25, S.32-3; 34-11;

T.26, S.8-5; 28-8; 29-3; 30-3; 31-4;
S.32-7; 35-3;

T.27, S.2-8;

T.28, S.33-3;

T.30, S.4-3; 5-3; 7-3; 8-6; 9-3; 10-4;
S.17-3; 19-6; 22-6; 23-7; 24-6;
S.25-3; 26-11; 27-9; 28-5; 30-4;
S.31-6; 33-3; 36-4;

T.31, S.1-12; 2-8; 3-4; 4-4; 5-9; 6-3;
S.8-3; 9-3; 11-4; 12-4; 15-5;

WEST OF THE 4th. MERIDIAN

Range 23.

T.31, S.30-3; 34-6; 35-4;

T.32, S.6-5; 20-4;

T.33, S.25-4;

T.34, S.3-3; 16-3; 20-4; 23-6; 28-3;

S.33-3; 34-3;

T.35, S.2-5; 7-3; 10-4; 16-3;

T.36, S.10-3; 15-3;

T.37, S.21-4; 25-5;

T.38, S.2-9; 5-6; 12-4; 32-4;

T.39, S.36-3;

T.40, S.2-5; 15-6;

T.42, S.5-3;

T.43, S.4-4; 5-3; 8-4; 14-4; 16-4;

S.30-7;

T.44, S.1-3;

T.46, S.11-5; 14-5; 15-5; 16-3

T.47, S.2-4; 4-3; 5-3; 14-4;

T.52, S.8-3; 32-3;

T.54, S.34-3;

T.60, S.34-3; 35-3; 36-3;

T.61, S.2-3; 3-3;

Range 24.

T.19, S.5-5; 7-3; 18-3; 28-3;

T.24, S.29-3;

WEST OF THE 4th. MERIDIAN

Range 24.

T.26, S.4-5; 17-3; 19-4; 29-3; 35-4;

T.27, S.21-5;

T.29, S.4-3; 20-5; 24-6; 28-3;

T.30, S.1-4; 2-5; 8-3; 9-3; 10-6;

S.12-4; 16-3; 17-3; 18-12;

S.20-8; 22-5; 24-9; 25-3; 29-3;

S.35-3; 36-7;

T.31, S.3-3; 5-6; 34-4; 36-3;

T.32, S.14-7; 24-7; 26-4; 35-4;

T.34, S.14-4; 15-3; 16-4;

T.35, S.12-5; 34-5;

T.36, S.7-3; 17-3; 21-3;

T.37, S.32-3;

T.38, S.1-3;

T.39, S3-9; 4-3; 27-4;

T.40, S.5-3; 24-5; 30-3;

T.41, S.8-3; 28-4;

T.42, S.22-4; 27-4; 31-5; 33-4;

T.43, S.2-5; 16-5; 17-4; 18-4;

T.44, S.32-4;

T.45, S.9-4;

WEST OF THE 4th. MERIDIAN

Range 24.

T.46, S.9-3; 14-5; 35-3;

T.47, S.3-3

T.58, S.30-3;

T.59, S.1-3; 3-3;

Range 25.

T.13, S.13-3;

T.15, S.22-5;

T.18, S.28-3; 29-3; 32-4; 34-4; 35-4;

T.19, S.1-7; 4-3; 5-5; 21-6; 30-6;
S.32-3;

T.20, S.21-3; 24-4; 33-4; 36-3;

T.21, S.23-3;

T.22, S.18-3; 19-3;

T.24, S.8-3; 9-3; 28-4; 36-3;

T.25, S.2-4; 4-3; 14-3;

T.27, S.29-3;

T.28, S.4-3; 17-4; 19-3; 31-3;

T.29, S.24-3;

T.30, S.5-4; 7-5; 12-3; 14-3; 26-8;
S.30-4;

T.31, S.3-3; 4-3; 7-3; 10-4; 32-5;
S.36-5;

WEST OF THE 4th. MERIDIAN

Range 25.

T.32, S.9-4; 26-3;

T.36, S.12-3;

T.37, S.10-7; 16-3;

T.38, S.5-6; 25-3; 36-5;

T.39, S.2-6; 13-4; 20-7;

T.40, S.7-4; 9-3; 10-3; 16-3; 24-3;
S.27-4;

T.41, S.6-3; 7-6; 8-3; 20-3; 30-4;

T.42, S.6-6; 13-7; 16-3; 17-3; 19-3;
S.23-6; 26-3; 34-3;

T.43, S.4-3; 13-3; 23-4; 24-3; 28-6;
S.29-3; 32-4; 33-4; 34-11;

T.44, S.2-9; 16-3;

T.46, S.8-6; 35-3;

T.58, S.26-4; 36-3;

Range 26.

T.15, S.4-3;

T.16, S.2-3;

T.18, S.5-3; 36-4;

T.19, S.3-3; 25-6;

T.20, S.5-5; 11-3; 14-5; 15-5; 17-3;

T.21, S.6-5; 9-4; 31-8; 33-3;

WEST OF THE 4th. MERIDIAN

Range 26.

T.22, S.4-5; 11-3; 14-3; 16-4;
S.17-3; 20-4;

T.23, S.22-6; 34-4; 36-4;

T.24, S.27-3;

T.26, S.5-4; 9-3;

T.29, S.6-5; 8-4; 12-4; 16-3; 20-5;

T.30, S.2-3; 16-5; 23-4; 25-5;

T.31, S.1-5; 11-3; 15-3; 18-7; 19-7;
S.28-4; 29-3; 30-3; 34-4;

T.33, S.19-4; 23-3;

T.34, S.13-3;

T.35, S.17-3; 33-3;

T.36, S.21-9; 25-3; 27-3;

T.37, S.3-5; 9-4; 10-4; 16-3; 31-3;

T.38, S.9-3; 12-3;

T.39 S.3-9; 26-7; 32-3; 33-3;

T.40, S.5-5; 6-3; 18-3; 19-4; 21-6;
S.29-3; 30-5; 35-3;

T.41, S.22-4; 23-4; 25-5; 30-4;

T.42, S.7-3; 28-3; 30-4;

T.43, S.18-4; 19-4; 21-3; 28-3;
S.31-3; 33-4;

T.44, S.11-3; 18-3; 30-3; 33-3;

WEST OF THE 4th. MERIDIAN

Range 26.

T.45, S.9-4; 15-4; 30-3;

T.46, S.11-3; 15-3;

T.49, S.27-3; 28-3;

T.50, S.5-3; 8-3; 9-3;

Range 27.

T.15, S.34-4;

T.16, S.22-3;

T.17, S.17-3;

T.19, S.2-3; 9-5; 13-6; 22-5; 23-5;
S.24-7; 25-4; 26-3; 28-3;
S.29-3; 30-4; 33-4; 34-5; 35-5;

T.20, S.2-5; 3-3; 6-11; 10-3; 12-4;
S.16-12; 17-3; 18-4; 19-7;
S.22-3; 25-6; 26-4; 27-3; 29-8;
S.30-13; 31-6; 32-5;

T.21, S.7-4; 8-8; 9-11; 14-3; 25-4;
S.28-3;

T.22, S.13-4; 14-3; 35-4;

T.23, S.6-7; 34-3;

T.24, S.12-3; 15-3; 30-3;

T.25, S.12-4

T.26, S.1-4; 16-4; 18-4;

WEST OF THE 4th. MERIDIAN

Range 27.

T.27, S.27-3; 35-3;

T.28, S.10-4;

T.29, S.1-3; 6-3; 7-3; 15-3;
S.18-4; 22-4; 24-4; 34-4;

T.30, S.12-6; 20-4; 30-3; 31-5;
S.32-5;

T.31, S.8-3; 9-3; 16-3; 23-8;
S.24-5; 35-4;

T.32, S.23-3;

T.33, S.7-3; 27-3; 30-3; 32-6;
S.34-5; 36-3;

T.34, S.20-6;

T.35, S.4-3; 7-5; 20-4;

T.36, S.6-7; 16-3; 18-4; 20-4;
S.27-3; 32-4; 33-3;

T.37, S.1-4; 2-4; 7-4; 10-4; 16-4;
S.27-4; 28-3;

T.38, S.1-4; 7-3; 8-3; 16-3; 27-3;
S.30-3; 35-4;

T.39, S.3-3; 7-4; 17-3; 20-6; 22-5;
S.26-6; 27-3;

T.40, S.5-3; 7-3; 17-6; 19-4; 20-3;
S.23-3; 26-6; 28-12; 32-8;
S.35-8; 36-9;

WEST OF THE 4th. MERIDIAN

Range 27.

T.41, S.2-8; 6-4; 13-4; 14-4; 17-4;
S.18-3; 20-5; 22-3; 24-4;
S.26-6; 27-3; 28-3; 29-3;
S.30-3; 33-7; 34-8; 36-5;

T.42, S.12-6; 20-5; 23-6; 27-6;
S.34-3; 35-3, 36-5;

T.43, S.1-4; 4-3; 6-3; 8-4; 10-3;
S.12-6; 13-3; 14-3; 20-9;
S.22-7; 23-6; 26-3; 27-3;
S.28-3; 31-3; 34-5;

T.44, S.18-4;

T.46, S.12-5; 17-5;

Range 28.

T.19, S.12-3; 28-4; 34-3; 36-3;

T.20, S.2-3; 10-8; 11-3; 12-8;
S.13-3; 16-4; 20-6; 23-4;
S.24-3; 26-5; 27-5; 29-3;
S.33-4; 34-5; 35-4;

T.21, S.4-3; 6-3; 8-6; 11-3; 18-5;
S.28-3; 31-3;

T.22, S.6-3; 12-4; 22-3; 32-7; 35-5;

T.23, S.2-3; 18-4; 19-3;

T.24, S.17-3;

WEST OF THE 4th. MERIDIAN

Range 28.

T.25, S.29-3;

T.26, S.1-15; 17-3; 19-3; 30-4; 36-4;

T.27, S.11-3; 24-3;

T.28, S.4-3; 10-5; 12-3; 21-3; 28-3;
S.32-5; 36-3;

T.29, S.34-5; 35-3;

T.30, S.28-3; 35-3;

T.31, S.1-3; 2-5; 12-3; 18-5; 20-3;
S.24-3; 29-6; 31-5;

T.32, S.5-5; 6-4; 7-8; 10-3; 12-5;
S.13-3; 18-5; 27-5; 31-3;

T.33, S.2-5; 3-5; 11-3; 20-6; 21-5;
S.27-3; 32-4;

T.34, S.20-5;

T.35, S.15-5; 25-6; 30-3; 32-3; 36-4;

T.36, S.12-5; 14-3; 15-3;

T.38, S.17-3;

T.39, S.20-5; 22-4; 27-3;

T.40, S.1-3; 4-3; 12-3; 16-3; 20-3;
S.36-3;

T.41, S.1-5;

T.42, S.25-3;

T.43, S.11-4; 12-6; 24-3; 36-6;

Range 28.

T.44, S.1-3; 12-4;

T.45, S.27-3;

T.49, S.13-4; 23-3; 24-3; 26-4;

Range 29.

T.18, S.20-4;

T.20, S.13-4; 20-7; 22-5; 27-7;

T.21, S.2-3; 4-3; 5-4; 6-12; 8-15;

S.12-8; 20-5; 21-3; 24-5;

S.27-3; 28-8; 33-3;

T.22, S.5-5;

T.24, S.11-5;

T.25, S.3-3, 27-3;

T.26, S.13-4; 35-3;

T.27, S.2-4; 23-3;

T.28, S.3-3; 15-7;

T.29, S.10-3;

T.30, S.1-3; 2-4; 13-3;

T.31, S.24-5;

T.32, S.14-3;

WEST OF THE 5th. MERIDIAN

Range 1.

T.19, S.2-3; 29-3; 32-4;

T.20, S.3-4; 15-4; 17-6; 22-5; 25-4;
S.28-8; 30-4; 31-3; 33-8; 34-3;
S.36-4;

T.21, S.2-16; 4-3; 26-8; 31-3; 36-3;

T.22, S.2-3; 6-4; 11-4; 13-3; 15-3;
S.16-7; 17-8; 19-4; 20-4; 21-3;
S.28-3; 32-3;

T.25, S.25-6; 26-7;

T.26, S.2-4; 8-4; 11-4; 14-4; 20-5;
S.21-4; 28-6; 29-3;

T.27, S.1-4; 5-3; 18-5; 19-7; 20-3;
S.25-3; 26-3; 32-3;

T.28, S.19-3; 20-3; 23-4; 29-3; 30-3;

T.29, S.2-3; 6-3; 12-5; 15-4; 18-3;
S.22-4; 34-5;

T.30, S.3-8; 4-5; 6-6; 7-3; 8-3;
S.10-5; 12-7; 13-3; 14-3; 17-7;
S.22-3; 23-4; 28-7; 29-3; 30-3;
S.32-7; 33-6; 35-3;

T.31, S.6-3; 11-7; 13-6; 20-5; 29-5;
S.33-5; 35-5;

T.32, S.2-3; 3-5; 9-4; 10-5; 11-11;
S.15-3; 16-4; 17-8; 18-3; 23-4;
S.30-4; 32-3;

WEST OF THE 5th. MERIDIAN

Range 1.

T.33, S.2-4; 13-3; 32-3;

T.34, S.1-4; 14-3; 23-5; 27-7; 32-5;

T.35, S.7-4; 8-5; 11-4; 13-5; 34-3;

T.36, S.2-3; 4-3;

T.37, S.1-3; 12-3; 20-5; 34-6;

T.38, S.1-4; 3-3; 10-4; 17-5; 25-3;
S.27-5; 28-7; 29-3; 30-6; 31-7;
S.32-10; 34-3;

T.39, S.1-4; 19-8; 21-3; 22-3; 24-4;
S.26-5; 27-5;

T.40, S.8-6; 24-5; 27-11; 35-7;

T.41, S.6-7; 21-6; 30-3;

T.42, S.6-3; 17-8; 30-5;

T.43, S.16-3; 18-5; 22-4; 30-3;

T.44, S.9-5; 35-4;

T.49, S.25-4; 26-3;

Range 2.

T.18, S.25-3;

T.19, S.22-4; 26-5; 34-5;

T.20, S.4-10; 8-6; 14-5; 18-4; 23-14;
S.30-7; 31-9;

T.21, S.2-5; 4-3; 5-6; 26-4;

WEST OF THE 5th. MERIDIAN

Range 2.

T.22, S.1-10; 14-3; 19-9; 23-18;
S.24-3; 25-25; 26-3; 29-5;
S.35-4; 36-5;

T.27, S.4-5; 26-3; 27-3; 34-5;

T.28, S.9-10; 10-6; 16-9; 24-3; 26-4;

T.29, S.6-5; 12-7; 13-5; 14-9; 20-18;
S.21-9; 22-5; 23-5; 24-4; 28-7;
S.30-4; 32-10; 34-4;

T.30, S.1-5; 3-3; 4-3; 5-11; 15-3;
S.16-9; 18-10; 24-7; 26-3; 33-3;
S.34-5; 35-3;

T.31, S.2-3; 3-4; 6-4; 8-5; 14-9; 15-3;
S.18-4; 19-5; 23-3; 26-20; 27-3;
S.32-3; 34-3; 36-4;

T.32, S.2-4; 4-9; 26-3; 33-6;

T.33, S.10-3; 28-3; 35-3;

T.34, S.29-5; 36-4;

T.35, S.28-3; 33-3;

T.36, S.2-3; 6-5; 13-3; 17-5; 23-3;

T.37, S.12-4; 20-6; 24-5; 30-3; 31-5;

T.38, S.1-3; 4-10; 5-8; 6-12; 8-3; 9-8;
S.10-3; 12-7; 14-3; 16-4; 18-3;
S.22-3; 23-3; 25-6; 28-4; 30-3;
S.31-4; 34-4; 35-3; 36-4;

WEST OF THE 5th. MERIDIAN

Range 2.

T.39, S.1-5; 3-3; 9-3; 11-5; 19-3;
S.30-6; 35-3;

T.40, S.3-7;

T.41, S.1-4; 17-3; 24-3; 35-4; 36-5;

T.42, S.2-5; 7-3; 14-3; 15-3; 22-4;
S.24-5; 29-4; 31-3; 34-5; 35-5;
S.36-7;

T.43, S.2-4; 3-5; 4-7; 5-4; 6-6;
S.10-12; 13-3; 14-3; 15-4;
S.16-4; 21-4; 22-3; 24-4; 25-3;
S.31-3;

T.44, S.22-5; 32-4;

T.45, S.3-3;

T.47, S.22-3;

T.48, S.17-3; 25-3;

T.49, S.13-3; 32-3;

T.50, S.8-4; 18-3; 28-3;

Range 3.

T.18, S.14-7;

T.19, S.22-8; 27-4; 35-3; 36-3;

T.20, S.8-3; 11-6; 15-3; 22-7; 26-4;
S.30-3;

T.21, S.10-6; 11-5; 26-5; 33-9; 34-12;

WEST OF THE 5th. MERIDIAN

Range 3.

T.22, S.15-4; 21-4; 25-7; 28-9;
S.31-4; 34-5;

T.24, S.22-5;

T.25, S.21-4;

T.26, S.7-3; 19-3; 31-3; 35-5;

T.27, S.2-4; 29-7; 30-7;

T.28, S.2-4; 9-3; 10-3; 17-4; 20-6;

T.29, S.14-5; 15-5; 17-3; 22-8;
S.27-4; 29-3; 30-3; 31-3;
S.34-7; 35-4; 36-9;

T.30, S.1-6; 2-8; 6-3; 24-5; 31-5;
S.35-3; 36-4;

T.31, S.1-5; 2-8; 6-3; 24-5; 31-3;
S.35-3; 36-4;

T.32, S.5-3; 6-3; 8-8; 12-7; 17-6;
S.20-5; 22-6; 24-3; 27-3; 30-3;
S.32-3; 34-9;

T.33, S.2-6; 3-4; 4-7; 5-4; 8-4; 12-3;
S.22-4; 23-4; 24-11; 30-5; 31-12;
S.34-4; 36-5;

T.34, S.3-4; 4-3; 6-4; 14-4; 22-5; 25-4;

T.35, S.17-4; 36-4;

WEST OF THE 5th. MERIDIAN

Range 3.

T.36, S.5-4; 12-3; 13-3; 17-6; 18-5;
S.23-4; 26-4; 33-4; 36-13;

T.37, S.2-3; 3-4; 5-6; 17-8; 20-3;
S.22-4; 26-3; 27-4; 30-4; 36-3;

T.38, S. 5-5; 7-8; 8-3; 9-4; 13-3;
S.15-7; 22-4; 28-3; 34-11;

T.39, S.6-6; 18-6; 22-3; 24-4; 26-14;

T.40, S.3-6; 13-8; 21-4; 23-4;

T.41, S.13-3; 28-3;

T.42, S.10-10; 11-3; 30-3;

T.43, S.1-5; 2-11; 4-3; 12-3; 13-7;
S.14-3; 17-7; 18-3; 25-5; 35-4;
S.36-5;

T.44, S.3-6; 14-5;

T.45, S.1-3; 3-3; 9-4; 12-5;

T.46, S.3-6; 19-5; 20-4; 35-11;

T.50, S.25-5;

Range 4.

T.19, S.35-3;

T.22, S.28-8; 36-5;

T.25, S.15-9; 34-5;

T.26, S.1-4; 12-3; 27-3;

WEST OF THE 5th. MERIDIAN

Range 4.

T.27, S.6-6; 17-3; 19-4; 23-4; 30-5;
S.32-5; 33-3;

T.28, S.27-8; 29-3; 34-8;

T.29, S.18-8; 19-4; 21-5; 22-5; 23-5;
S.28-6; 29-3; 30-5; 32-12; 35-4;
S.36-4;

T.30, S.3-8; 4-6; 5-4; 9-9; 10-9; 12-3;
S.13-7; 14-7; 16-3; 21-3; 23-6;
S.24-4; 25-3; 34-3; 35-13;

T.31, S.2-4; 5-13; 15-7; 32-6; 33-3;
S.36-4;

T.32, S.4-4; 8-3; 10-7; 16-8; 22-18
S.24-4; 25-3; 27-4; 30-5; 33-3;
S.36-4;

T.33, S.6-3; 12-7; 13-8; 14-3; 19-9;
S.20-4; 22-10; 25-4; 27-15; 29-5;
S.30-3;

T.34, S.6-5; 10-4;

T.35, S.2-3; 5-3; 16-3; 19-10; 20-3;
S.28-8; 35-7; 36-4;

T.36, S.12-4; 16-3;

T.37, S.10-3; 11-4; 12-3; 13-10; 14-4;

WEST OF THE 5th. MERIDIAN

Range 4.

T.37, S.18-3; 24-4; 30-5; 31-7; 33-6;
S.34-11;

T.38, S.1-4; 2-14; 4-5; 6-4; 7-5; 12-11;
S.15-3; 16-8; 22-6; 29-8;

T.39, S.1-13; 33-7;

T.40, S.4-12; 5-3; 15-4; 25-6; 27-4;
S.28-3; 34-8;

T.41, S.1-4; 20-3; 31-4; 33-10; 35-7;
S.36-3;

T.42, S.12-5; 14-7; 15-3; 22-4; 23-5;
S.32-3;

T.43, S.31-7; 33-3;

T.44, S.9-3; 10-3; 20-3; 36-3;

Range 5.

T.19, S.33-3;

T.23, S.9-3; 13-4;

T.27, S.10-3; 11-5; 12-4; 22-3; 24-3;
S.25-8; 34-4;

T.28, S.24-4; 28-4;

T.30, S.5-6; 9-5; 12-4; 13-3; 23-5;
S.29-18; 30-3;

T.31, S.2-3; 4-6; 9-6; 36-3;

WEST OF THE 5th. MERIDIAN

Range 5.

T.32, S.3-5; 7-3; 10-3; 14-3; 16-8;
S.19-6; 31-6; 35-9;

T.33, S.2-3; 16-7; 24-8; 28-4; 30-7;
S.33-22; 34-5; 35-5;

T.34, S.5-3; 7-3; 9-3; 23-3; 27-9;
S.31-7; 34-4;

T.35, S.19-3; 22-4; 25-6;

T.36, S.4-4; 11-4; 14-3; 16-3; 21-3;
S.23-5;

T.37, S.24-4; 25-3; 35-3; 36-3;

T.38, S.7-4; 10-8; 16-9; 19-7; 35-4;
S.36-5;

T.39, S.4-4; 6-3; 23-4; 28-4; 32-5;

T.40, S.4-3; 15-4; 24-3; 25-4; 33-4;

T.41, S.19-7; 27-6; 31-9; 32-4; 36-4;

T.43, S.14-10;

T.45, S.34-3

T.46, S.5-3; 8-3; 9-4;

T.52, S.26-4; 28-4; 33-4;

Range 6.

T.26, S.27-8;

T.31, S.2-13; 35-6;

T.32, S.2-3; 15-9;

WEST OF THE 5th. MERIDIAN

Range 6.

T.33, S.7-3;

T.34, S.11-4; 22-3;

T.35, S.34-6; 36-5;

T.36, S.4-4; 10-4; 24-4; 25-3; 36-4;

T.37, S.8-4; 9-6; 18-4; 26-3; 31-3;

T.38, S.22-4; 25-3; 27-3; 31-3; 32-3;
S.33-3;

T.39, S.30-13; 34-4;

T.40, S.4-3; 9-4; 10-7; 12-3; 16-6;
S.22-5; 27-5; 34-3;

T.41, S.9-6; 10-4;

T.44, S.4-4; 18-4;

T.46, S.11-3;

Range 7.

T.33, S.16-3; 27-5;

T.34, S.3-6; 5-3;

T.36, S.2-16; 14-3; 22-4;

T.37, S.31-3;

T.38, S.1-3; 12-6; 15-6; 17-5; 33-3;
S.35-3; 36-6;

T.39, S.4-7; 7-4; 8-4; 14-15; 16-13;
S.22-6; 23-3;

WEST OF THE 5th. MERIDIAN

Range 7.

T.47, S.5-3;

T.53, S.10-3;

Range 8.

T.37, S.27-3; 31-4; 34-3;

T.38, S.5-13; 6-4; 22-3;

T.39, S.12-8;

T.41, S.5-4;

T.52, S.1-3; 10-4; 12-3; 15-3;

T.53, S.22-3;

Range 9.

T.38, S.13-3; 14-3;

T.47, S.8-3;

Range 11.

T.54, S.4-3; 8-5; 17-4; 18-4; 20-5;

Range 13.

T.40, S.35-4;

Range 15.

T.40, S.34-4;

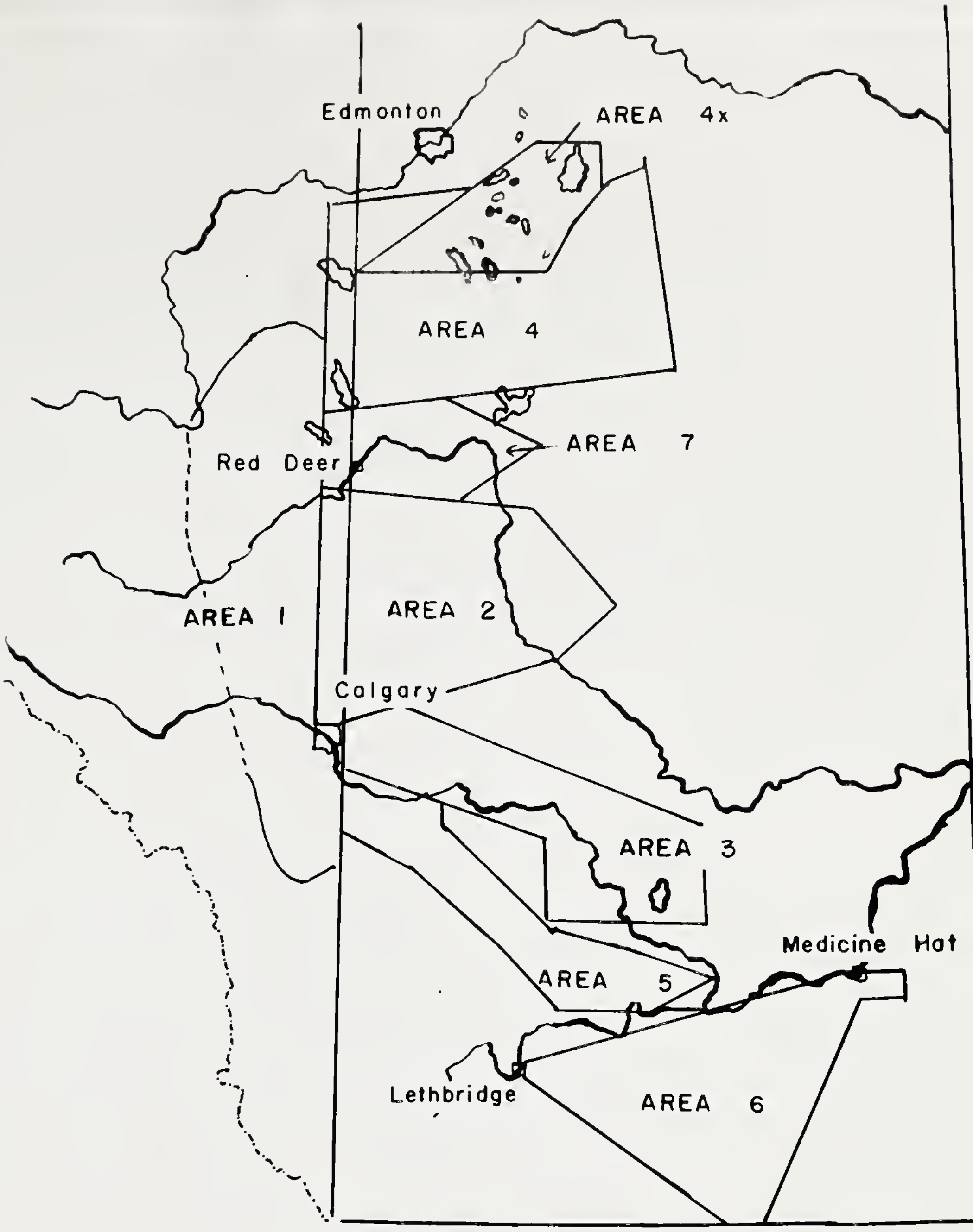
Range 16.

T.54, S.27-3;

APPENDIX "B"

Map 9 outlines the seven areas or subdivisions which were used for convenience in analysis. The boundaries of these areas are based on the experience of the Alberta Hail Insurance Board from 1920 to 1956 but have been modified slightly to include the major concentrations of hail for the period 1951 to 1960. Area 1 is separated from the others for the statistical and physiographic detail is much less complete than for the other areas. It may well be that areas 3, 2, 7, and 4 extend westward into it but it would be difficult to establish even tentative boundaries for this area based on the information available at present.

The body of the appendix consists of the details of the physiographic features considered for each of the hail zones within the individual areas. There are two maps for each area, the first showing the distribution and frequency of hail for that area and the second some of the major physical features within the area.



ALBERTA

HAIL AREAS, 1951-1960

Boundaries modified from the map of the Alberta Hail Insurance Board

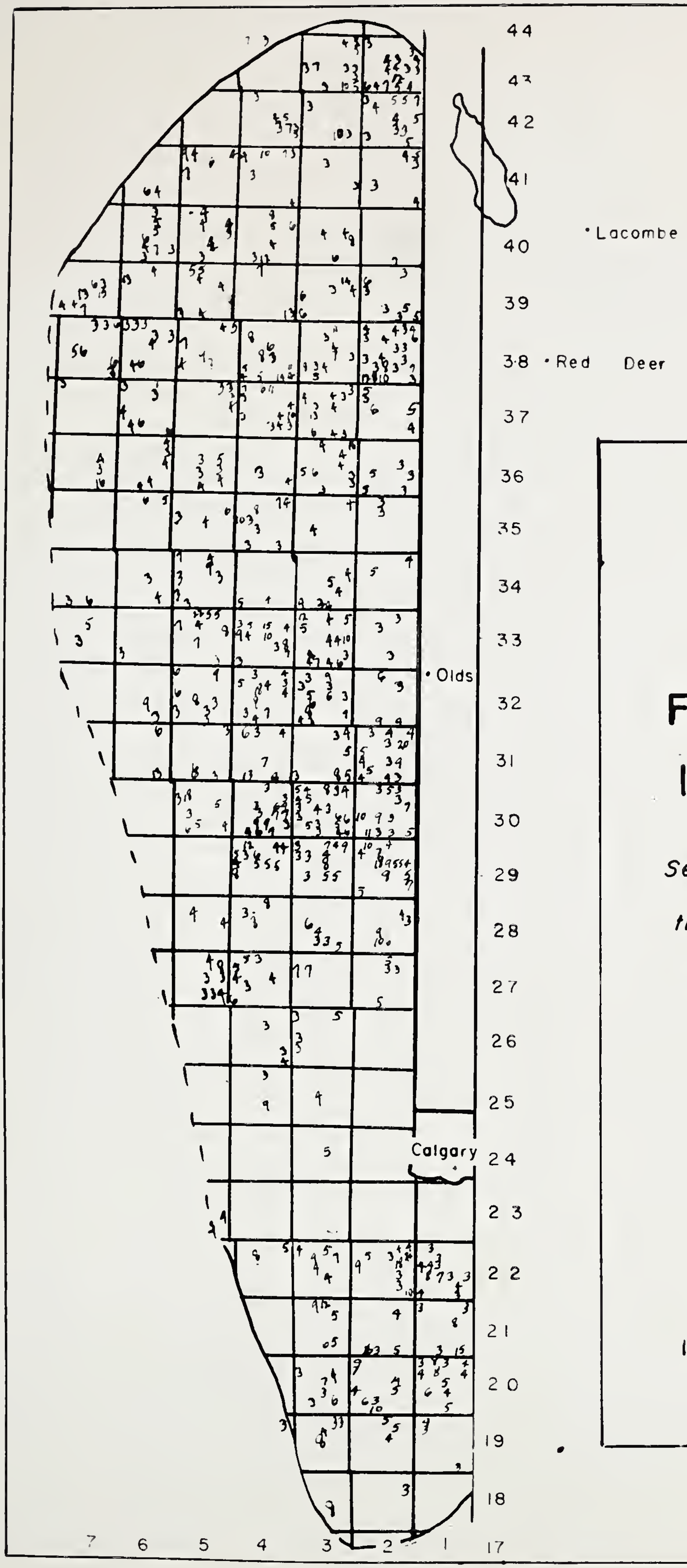
SCALE

64 MILES TO 1 INCH

MAP 9

Area 1. (See maps 10 and 11.)

This area is west of Calgary, Olds, Red Deer and Lacombe. The western boundary is indefinite due to the low density of population. The data on hail is scanty and detailed physiographic information is unavailable. Therefore, no distributional pattern can be seen to exist within this area.



ALBERTA

(HAIL AREA 1)

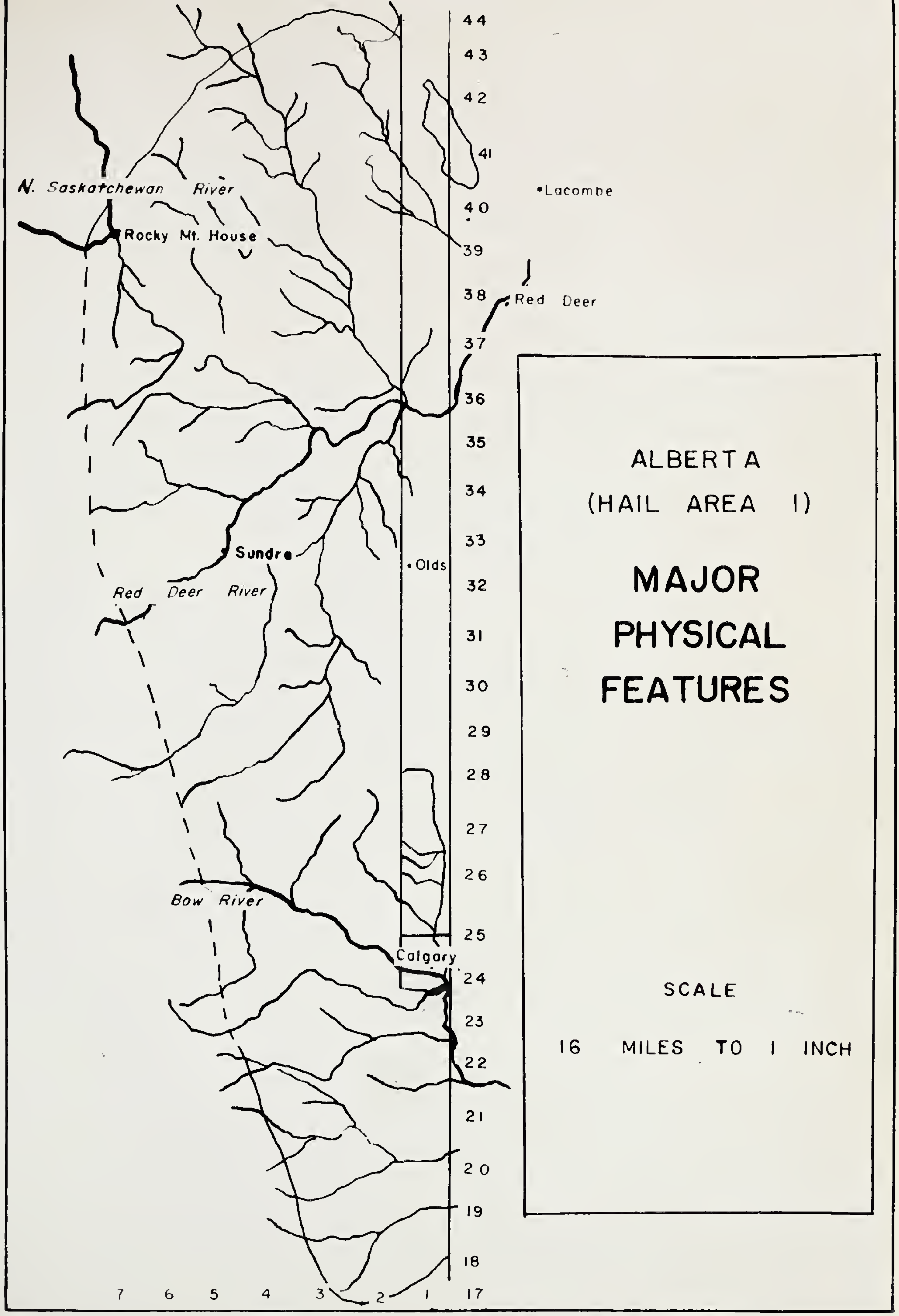
HAIL FREQUENCY, 1951—1960

Sections receiving hail three or more times during the period

SCALE

16 MILES TO 1 INCH

MAP 10


ALBERTA
(HAIL AREA 1)
MAJOR PHYSICAL FEATURES
SCALE
16 MILES TO 1 INCH
N. Saskatchewan River
Rocky Mt. House
Lacombe
Red Deer
Sundre
Olds
Red Deer River
Bow River
Calgary
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
7 6 5 4 3 2 1

MAP 11

Area 2. (See maps 12 and 13.)

(a) Range 19; Township 30.

1. local relief 125 feet
2. elevation 2575 to 2700 feet
3. aspect - a small portion has a slight western exposure but most of the area is flat with no exposure
4. no lakes and a few intermittent streams
5. valley is aligned north-south

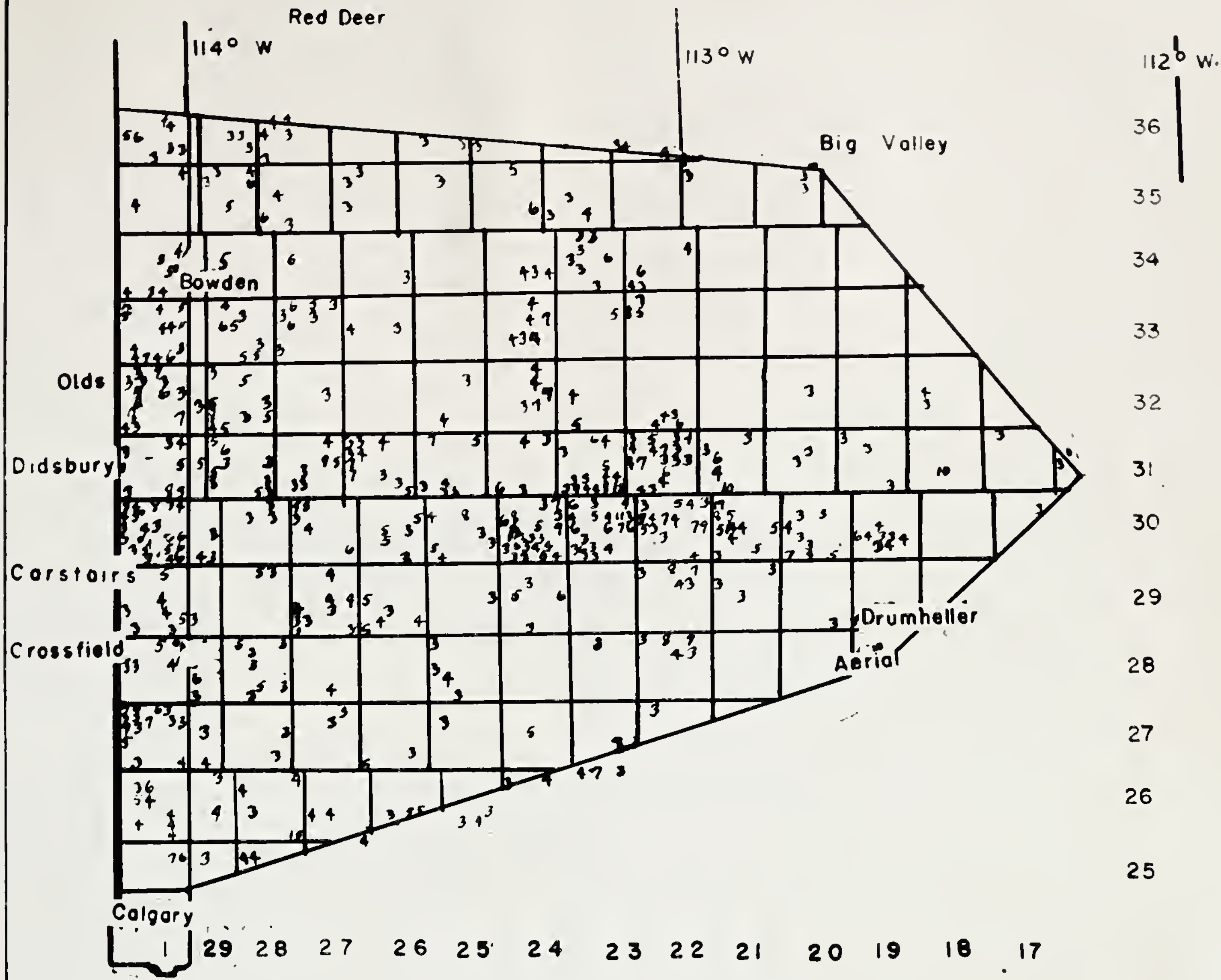
(b) Range 20; Township 30.

1. local relief 40 feet
2. elevation 2663 (Munson Junction) to 2700 feet
3. no definite exposure
4. a few intermittent lakes on the periphery
5. interfluve is aligned north-south to the west of the area

(c) (See Pilot Study in text.)

(d) Range 22; Townships 33 and 34.

1. local relief 300 feet
2. elevation 2500 to 2800 feet
3. aspect - eastern and northeastern
4. no lakes or streams except for the Red Deer River
5. valley is aligned northwest-southeast



ALBERTA (HAIL AREA 2)

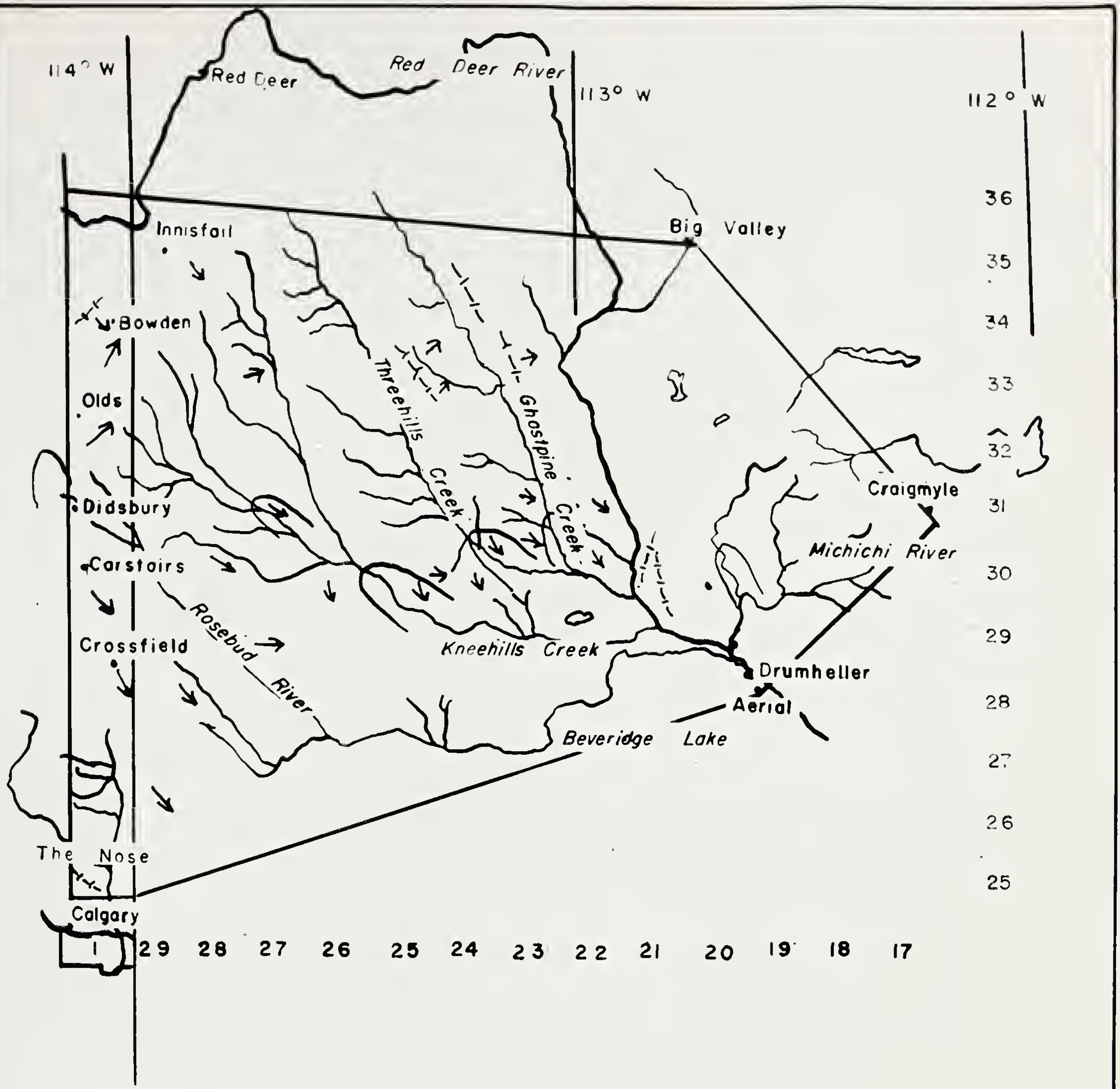
HAIL FREQUENCY, 1951—1960

Sections receiving hail three or more times during the period

SCALE

16 MILES TO 1 INCH

MAP 12



ALBERTA (HAIL AREA 2)

MAJOR PHYSICAL FEATURES

LEGEND

trend of valleys

hills or ridges

← direction of slope

SCALE

16 MILES TO 1 INCH

MAP 13

Area 2.

(e) Range 23; Townships 34 and 35.

1. local relief 200 feet
2. elevation 2900 to 3100 feet
3. aspect - southern and southeastern
4. no lakes or streams are evident
5. hail occurs at the southern end of a ridge below the crest on a gentle slope

(f) Range 24; Townships 32 to 35.

1. local relief 300 feet
2. elevation 2700 to 3000 feet
3. exposure tends to be northeastern but some southeastern aspects noted
4. no lakes, Ghostpine Creek to the east
5. creek and ridge aligned north-northwest to south-southeast with the hail on the west or lee bank

(g) Ranges 25 to 29; Townships 25 to 36.

1. surface very irregular and hail spotty
2. elevation 2800 to 3350 feet
3. aspect - east and south-facing slopes. Hail also occurred in the broad flat basins.
4. no hail around the small lakes
5. the only valley in the area has a north-northwest to south-southeast alignment

Area 2.

(h) Range 1; Townships 25 to 36, W. 5th Meridian.

1. local relief 600 feet - surface irregular
2. elevation 3275 to 3875 feet, hail generally found at lower elevations within area
3. aspect - eastern in most of the area
4. absence of hail around lakes
5. no definite alignment for valleys and hills. Note absence of hail on "The Nose" and similar ridges and hills

Area 3. (See maps 14 and 15.)

(a) Ranges 13 and 14; Township 16.

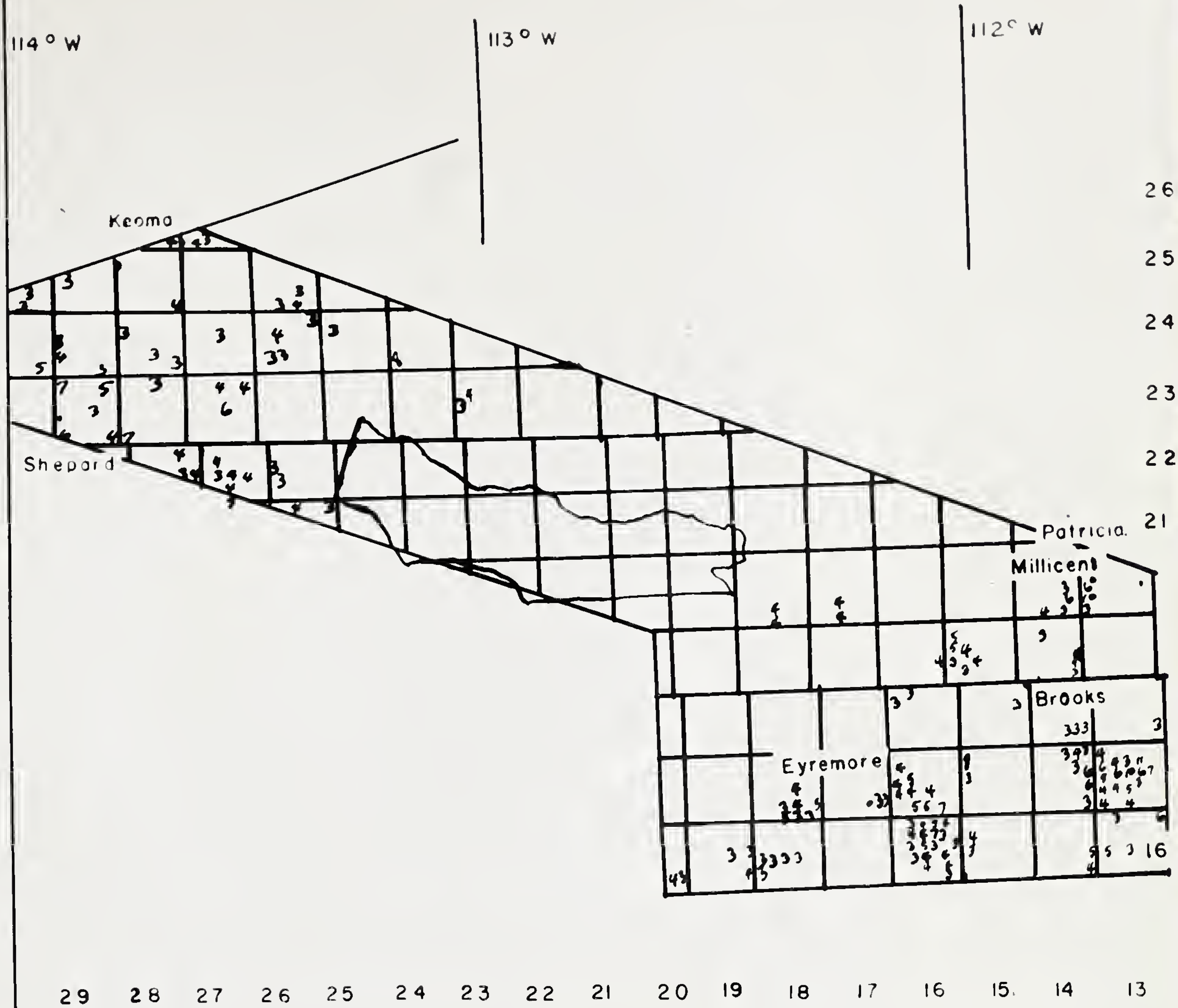
1. local relief 50 feet
2. elevation 2450 to 2500 feet, gentle gradient
3. slope aspect east
4. lakes around but not within the section, no hail near lakes, e.g. Lake Newell to northwest
5. little rolling hills to west are aligned north-south, tops of hills show a dearth of hail reports

(b) Ranges 12 to 14; Townships 17 and 18. (Brooks)

1. local relief 50 feet
2. elevation 2425 to 2475 feet, slope almost imperceptible
3. broad flat valley with hail concentrated in the southern section
4. where the lakes are prevalent there are no hail reports. Storm tracks tend to avoid the lakes and occupy about one-third of the valley floor
5. northwest to southeast alignment

(c) Range 14; Townships 19 and 20.

1. local relief 25 feet
2. elevation 2450 to 2475 feet
3. no exposure as land almost flat



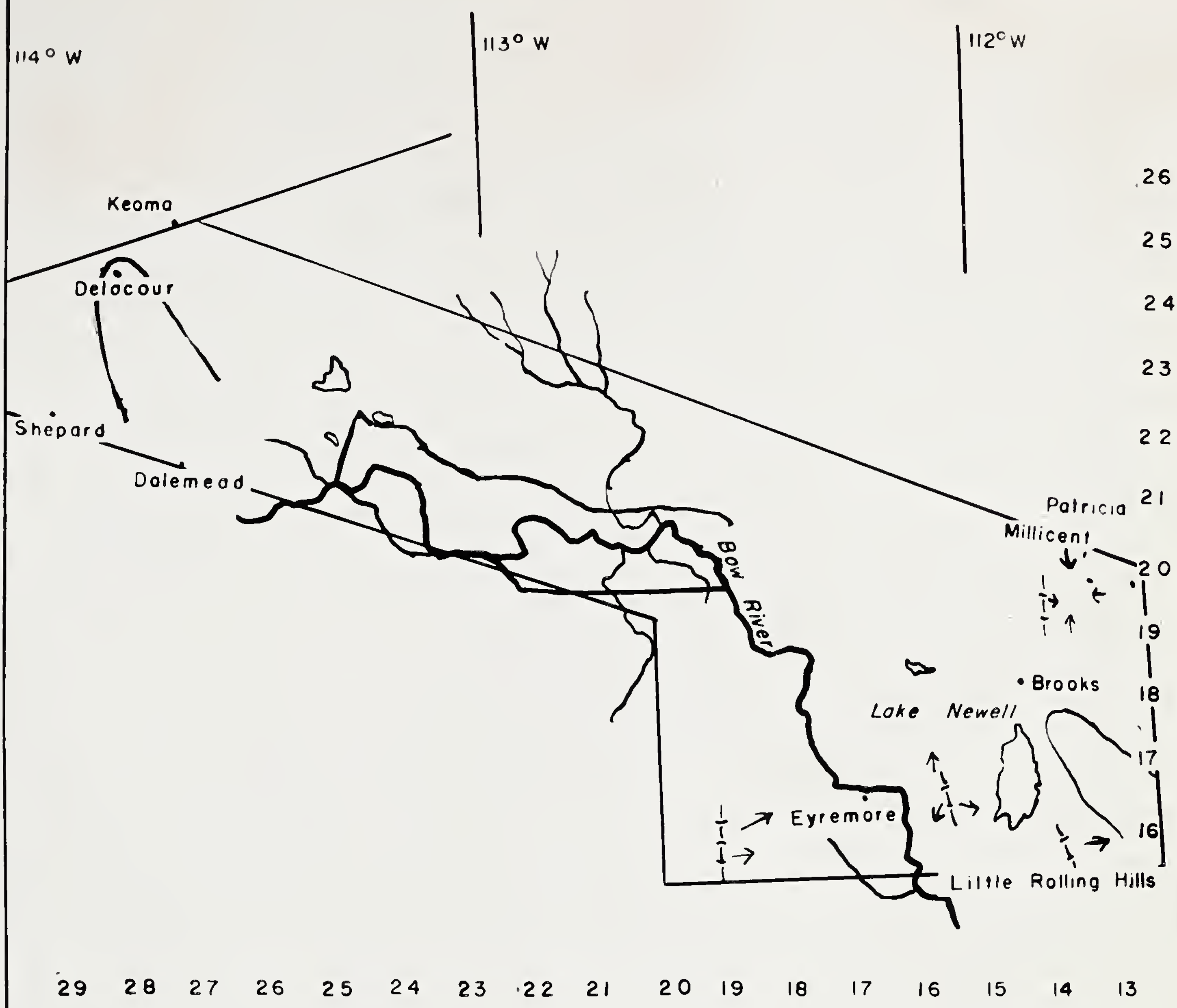
ALBERTA (HAIL AREA 3)

HAIL FREQUENCY, 1951–1960

Sections receiving hail three or more times during the period

SCALE

16 MILES TO 1 INCH



ALBERTA (HAIL AREA 3)

MAJOR PHYSICAL FEATURES

LEGEND

trend of valleys
hills or ridges
direction of slope

SCALE

16 MILES TO 1 INCH

MAP 15

Area 3.

(c) Cont'd.

4. no lakes, dry area - note irrigation ditches
5. hail track - north-south

(d) Range 15; Township 19.

1. local relief 50 feet
2. elevation 2475 to 2525 feet
3. hail concentrated in a depression or basin
4. several intermittent sloughs
5. depression and hail track aligned north-south

(e) Range 16; Townships 16 and 17.

1. local relief 50 feet
2. elevation 2450 to 2500 feet
3. aspect - eastern, and also hail along bottom of the valley
4. no lakes, Bow River trends north-south through centre of strip
5. "hail road" is twelve miles long, three to four miles wide on western bank of river and valley floor. Valley and hail strip trend north-south

Area 3.

(f) Range 18; Townships 16 and 17.

1. local relief 100 feet
2. elevation 2700 to 2800 feet, gentle gradient 100 feet in six miles
3. aspect - eastern
4. many intermittent lakes to the northwest
5. land higher to the west, ridge follows a north-south alignment

(g) Ranges 25 to 29; Townships 21 to 25.

1. local relief 300 feet
2. elevation 3300 feet to 3600 feet, very irregular surface
3. hail is widely scattered seeking the depressions within the area
4. a few small lakes and the Bow River forms the southern margin
5. from Delacour to Dalemead there is a northwest-southeast valley and a storm track is discernible although it is not particularly severe

Area 4. (See maps 16 and 17.)

(a) Ranges 14 to 16; Townships 42 and 43.

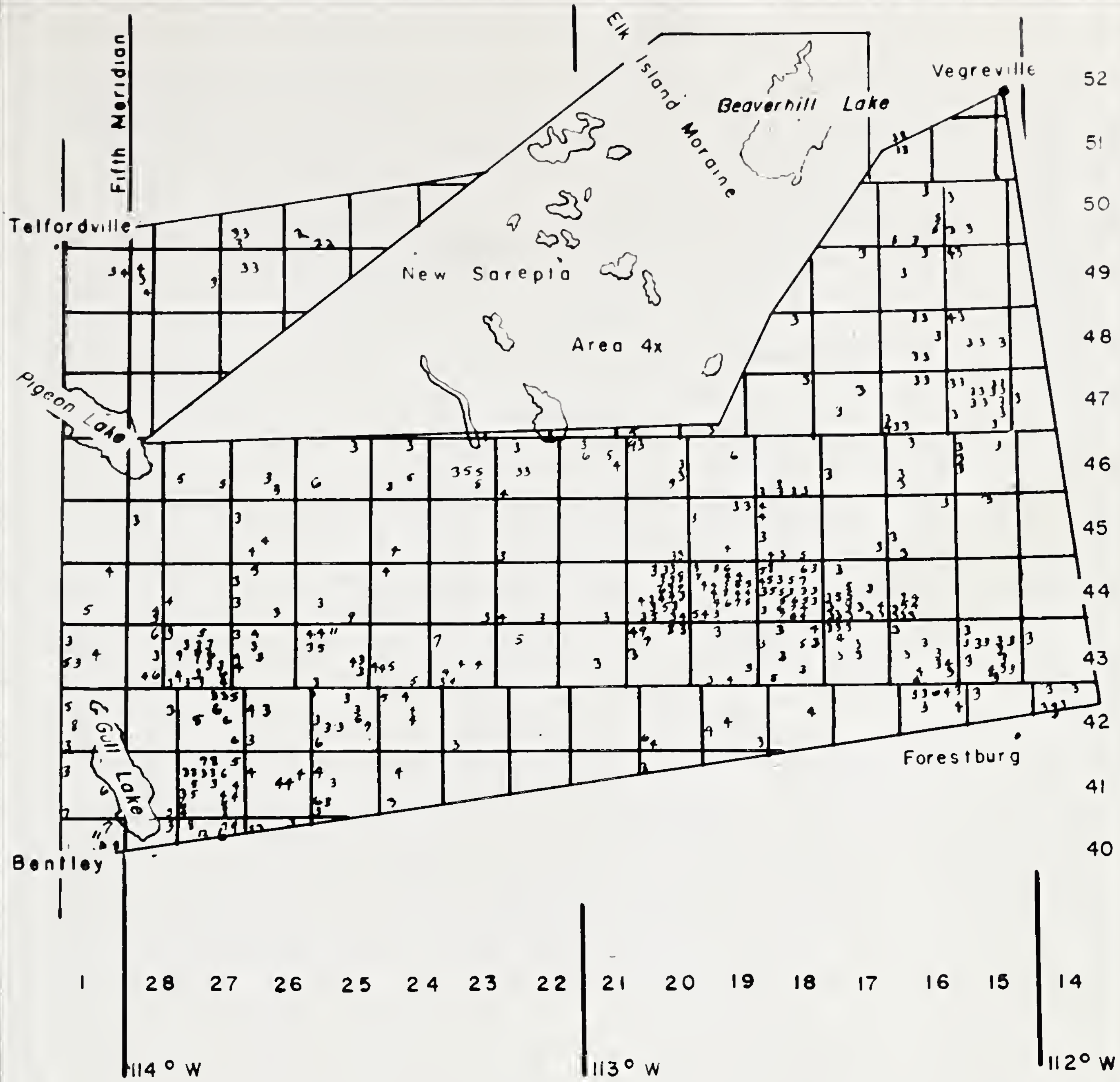
1. local relief slightly under 100 feet
2. elevation 2300 to 2400 feet, very gentle slope and gradient
3. aspect - northeastern but not pronounced
4. many small lakes on this broad flat area
5. ridge follows northwest to southeast orientation immediately east of Battle River. Hail found on slope below crest of ridge and at the base to the northwest

(b) Ranges 15 and 16; Townships 49 and 50. (Bruce)

1. local relief a little over 100 feet
2. elevation 2241 feet at Bruce to 2350 feet
3. northeastern exposure, land slightly higher and more level to the west
4. a few swampy patches and intermittent streams
5. hail occurs where the gradient increases from five feet per mile to twenty-five feet per mile

(c) Ranges 15 and 16; Townships 49 and 50.

1. local relief 100 feet
2. elevation 2200 to 2300 feet, very gentle slope
3. aspect - none in particular
4. no streams or lakes, a few swampy patches
5. storm track southwest to northeast



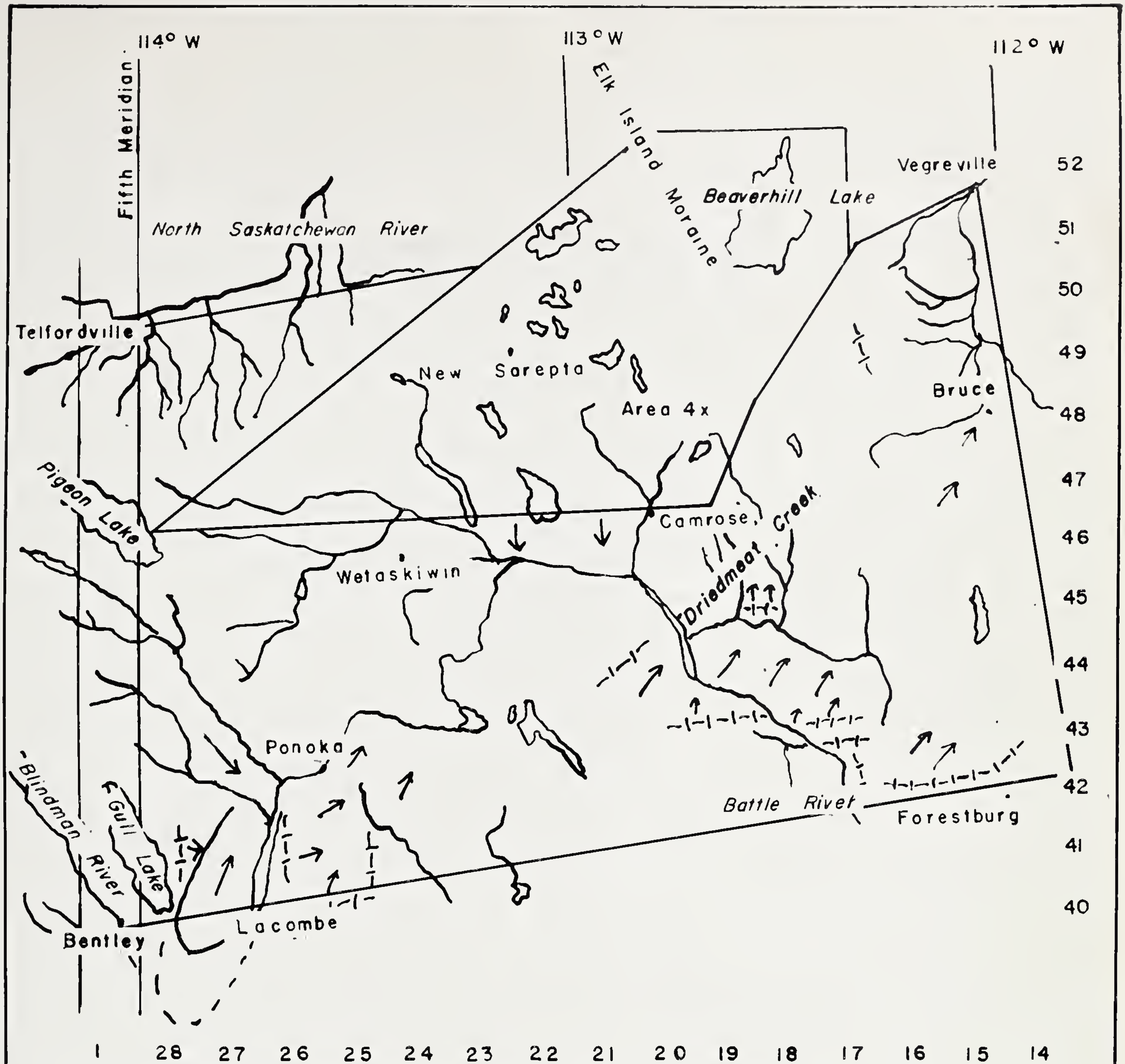
ALBERTA (HAIL AREA 4)

HAIL FREQUENCY, 1951—1960

Sections receiving hail three or more times during the period

SCALE
16 MILES TO 1 INCH

MAP 16



ALBERTA (HAIL AREA 4)

MAJOR PHYSICAL FEATURES

LEGEND

trend of valleys

hills or ridges

direction of slope

SCALE

16 MILES TO 1 INCH

MAP 17

Area 4.

(d) Ranges 16 to 20; Townships 43 and 44.

1. local relief 300 feet
2. elevation 2300 to 2600 feet
3. aspect - northeastern and northern
4. a few very small lakes
5. east-west strip of hail, very heavy concentration. Land higher to south but not a continuous ridge with hail below crests

(e) Range 18; Townships 45 and 46.

1. local relief 50 feet
2. elevation 2250 to 2300 feet, gentle slope
3. aspect - north
4. no lakes
5. Driedmeat Creek flows north-south with hail along its valley. This appears to be a northern extension of the area to the south (4d)

(f) Ranges 20 to 24; Township 46.

1. local relief slightly over 50 feet
2. elevation 2450 to 2500 feet
3. aspect - northern and northeastern
4. no lakes and only the Pipestone River
5. valley and ridge aligned east-west

Area 4.

(g) Ranges 23 to 26; Townships 41 to 43.

1. local relief 300 feet
2. elevation 2700 to 3000 feet, gentle gradient and irregular surface
3. aspect - north, northeastern and eastern
4. a few small kettle lakes
5. no pattern or trend to valleys or hills

(h) Ranges 26 to 28; Townships 40 to 45.

1. local relief 400 feet
2. elevation 2700 to 3100 feet, surface irregular and gradient is not constant
3. aspect - eastern
4. a few lakes and streams but none of the streams have well developed valleys
5. main ridge has a north northwest to south southeast alignment and is located to the west. No hail on the crest but concentrated on the slopes. The heaviest portion within the hail area is Range 27, Township 41, which appears to be a northward extension of area 7g.

(i) Ranges 25 to 28; Townships 49 and 50.

1. local relief 100 feet
2. elevation 2300 to 2400 feet, gentle slope
3. aspect - northern

Area 4.

(i) Cont'd.

4. North Saskatchewan River to the north
5. valley follows east-west direction

(j) Range 1; Townships 40 to 44, W. 5th.

1. local relief 300 feet
2. elevation 2850 to 3150 feet
3. aspect - the main hail strips face eastward
4. Gull Lake to the east, no hail directly around
5. Blind Man River flows through the central part of the area from the north-northwest to the south-southeast

Area 4x.

Ranges 17 to 28; Townships 47 to 52 (area included within these townships but does not cover all of them).

1. local relief 200 feet
2. elevation 2300 to 2500 feet, long gentle slope
3. aspect - western
4. many lakes and very swampy
5. no definite trend to valleys or hills as this area includes part of a moraine and pitted outwash and lacustrine plains (noted for its absence of hail)

Area 5. (See maps 18 and 19.)

(a) Range 13; Township 13.

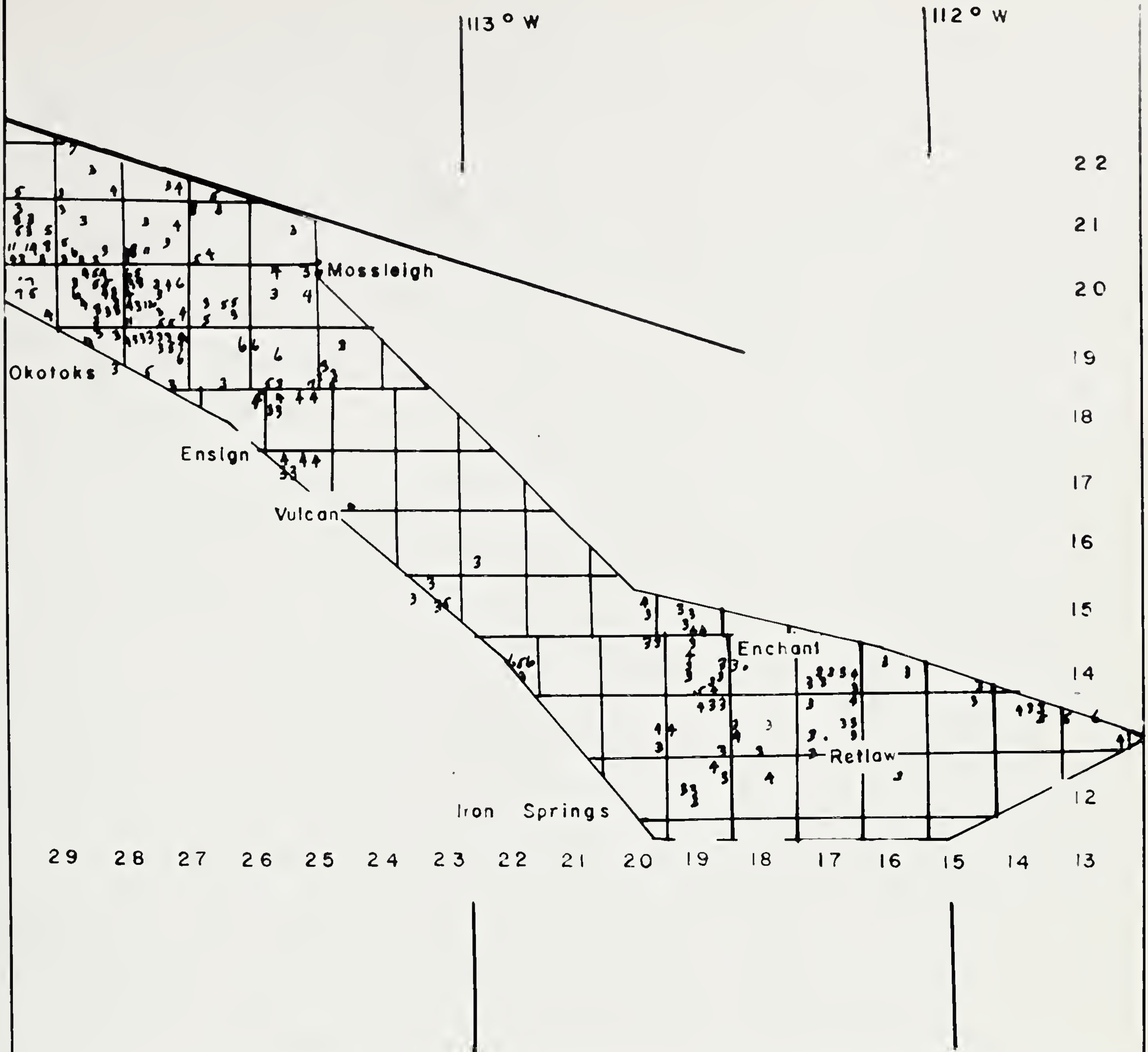
1. local relief 100 feet
2. elevation 2400 to 2500 feet, gentle slopes
3. aspect - southeast, half way down slope leading to Bow River
4. several intermittent sloughs
5. hill aligned southwest to northeast, hail track northwest to southeast or at right angles to ridge on the lee side

(b) Range 14; Township 13.

1. local relief 100 feet
2. elevation 2500 to 2600 feet, gentle slope
3. aspect - southeast below crest
4. lakes to northwest near Vauxhall
5. hill southwest to northeast with hail track at right angles to it

(c) Range 17; Townships 13 and 14. (Retlaw)

1. local relief 100 feet
2. elevation 2550 to 2650 feet, almost no slope
3. broad flat basin
4. intermittent lakes and sloughs
5. no pattern to physiographic features within basin



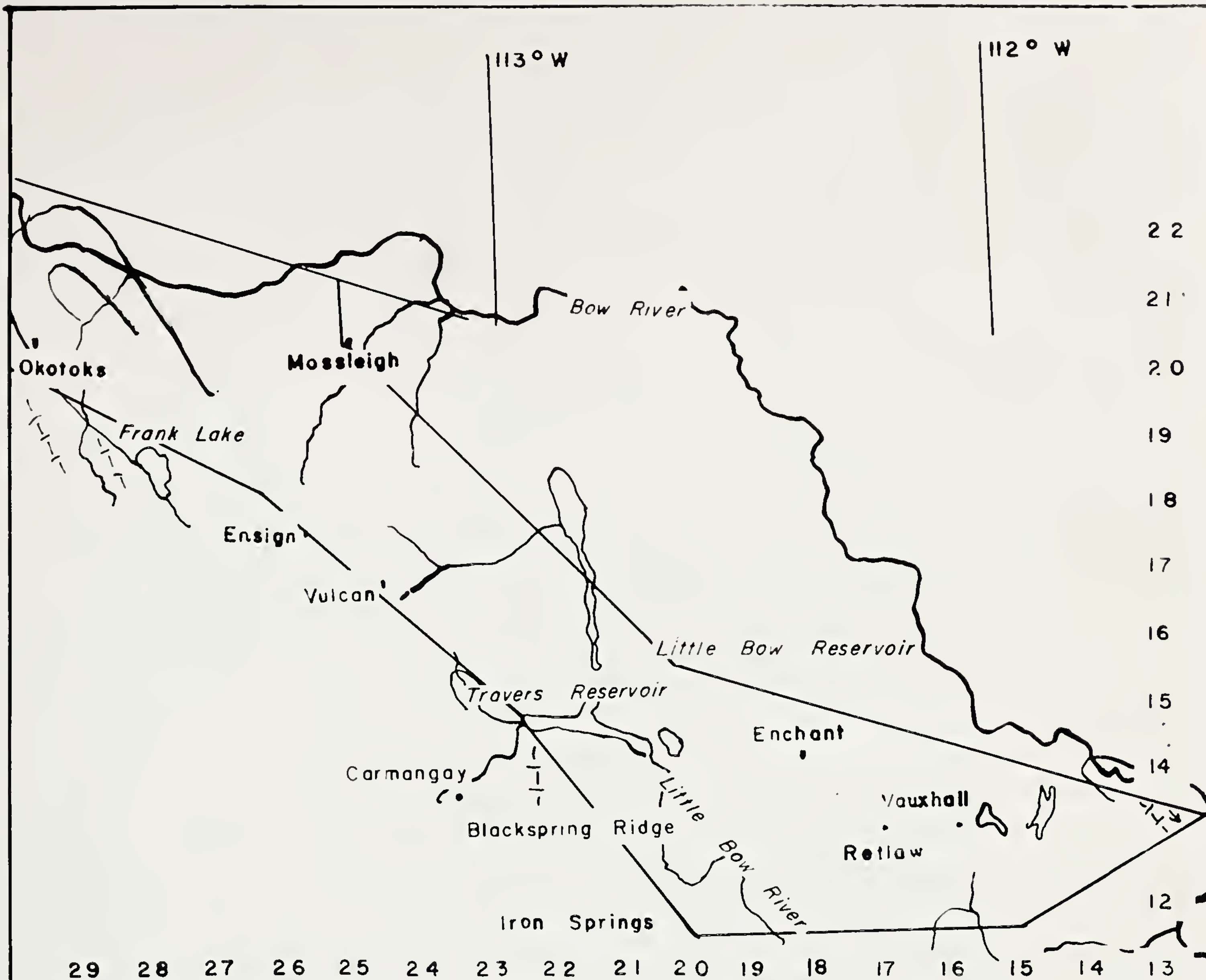
ALBERTA (HAIL AREA 5)

HAIL FREQUENCY, 1951–1960

Sections receiving hail three or more times during the period

SCALE
16 MILES TO 1 INCH

MAP 18



ALBERTA (HAIL AREA 5)

MAJOR PHYSICAL FEATURES

LEGEND

trend of valleys
hills or ridges
direction of slope

SCALE

16 MILES TO 1 INCH

MAP 19

Area 5.

(d) Range 19; Township 12.

1. local relief 100 feet
2. elevation 2700 to 2800 feet, gentle slope
3. aspect - eastern
4. absence of lakes and streams
5. valley of the Little Bow River north-south with hail concentrated on the western slope below the crest of the divide

(e) Range 19; Townships 13 to 15.

1. local relief 125 feet
2. elevation 2675 to 2800 feet, gentle slope
3. aspect - eastern with higher land to the west of the strip
4. two permanent lakes Travers and Little Bow Reservoirs
5. no particular alignment to hills or valleys

(f) Range 22; Township 14.

1. local relief 150 feet
2. elevation 3150 to 3300 feet, 150 feet in 4 miles
3. hail concentration on the eastern slope of Blackspring Ridge
4. a few intermittent streams
5. Blackspring Ridge, aligned north-south, dominates the landscape

Area 5.

(g) Range 23; Township 15.

1. local relief 50 feet
2. elevation 3050 to 3100 feet, 50 feet in 4 miles
3. hail concentrated in a broad flat basin
4. no lakes
5. basin is north of Little Bow River which flows west to east

(h) Ranges 25 to 29; Townships 16 to 22.

1. local relief 200 feet
2. elevation 3250 to 3450 feet, gentle gradient
3. broad flat valley from Okotoks and High River to Champion
4. a few intermittent lakes
5. valley is aligned in a northwest to southeast direction - storm track runs right down the length and breadth of it

Area 6. (See maps 20 and 21.)

(a) Range 4; Township 12.

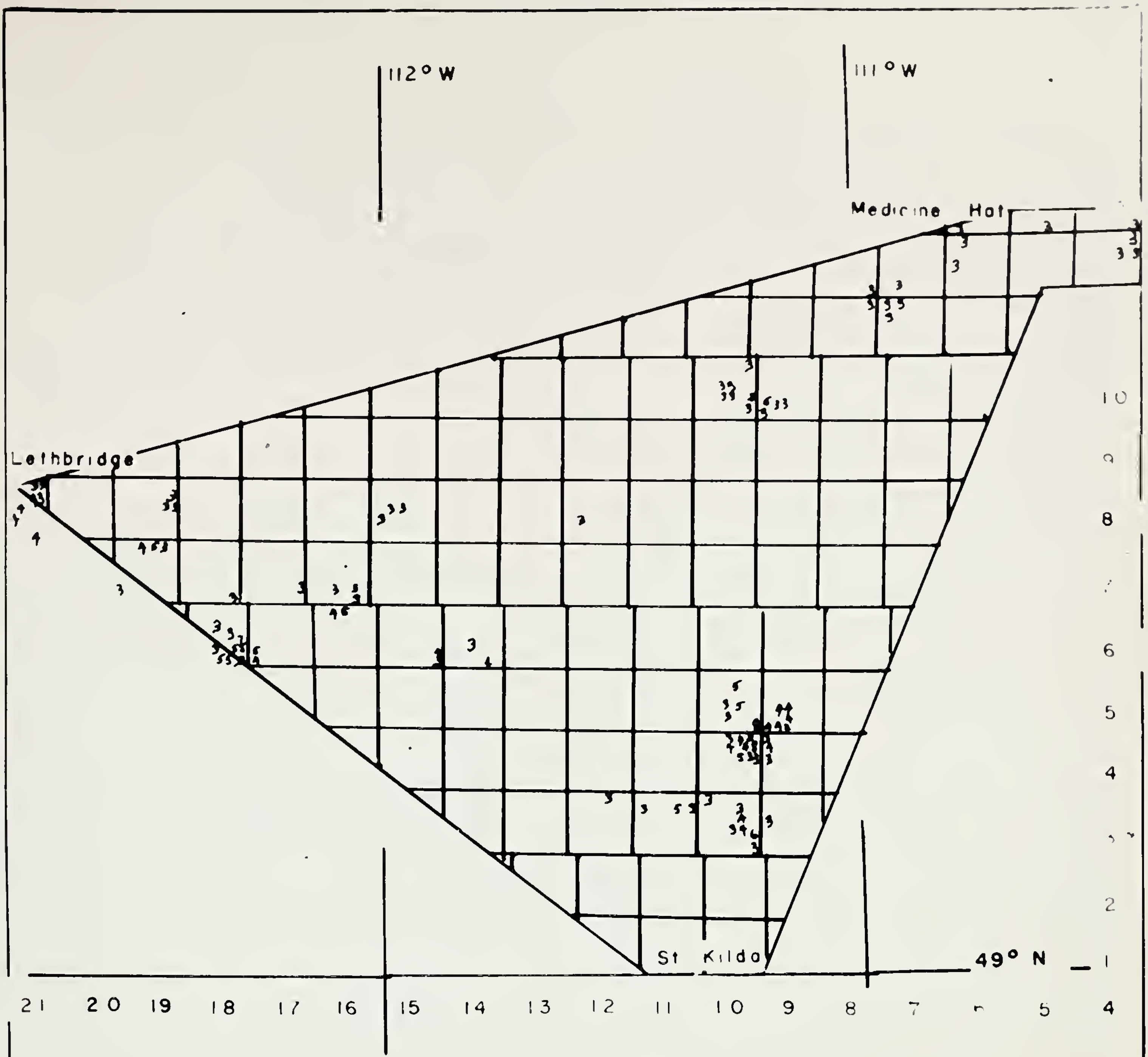
1. local relief 150 feet
2. elevation 2450 to 2600 feet, very gentle slope
3. broad flat depression centred in the township with very little hail outside the basin
4. many intermittent lakes and sloughs
5. moraine on the western edge has a northwest to southeast alignment

(b) Ranges 5 and 6; Township 12. (Medicine Hat)

1. local relief 250 feet
2. elevation 2250 to 2500 feet, gradient approximately 30 feet per mile
3. aspect - higher to the west with hail concentrated on the flat area near the top of the interfluve
4. many intermittent streams and sloughs
5. surface irregular with no apparent trend to the valleys or hills

(c) Ranges 7 and 8; Township 11.

1. local relief 100 feet
2. elevation 2600 to 2700 feet, gradient approximately 25 feet per mile

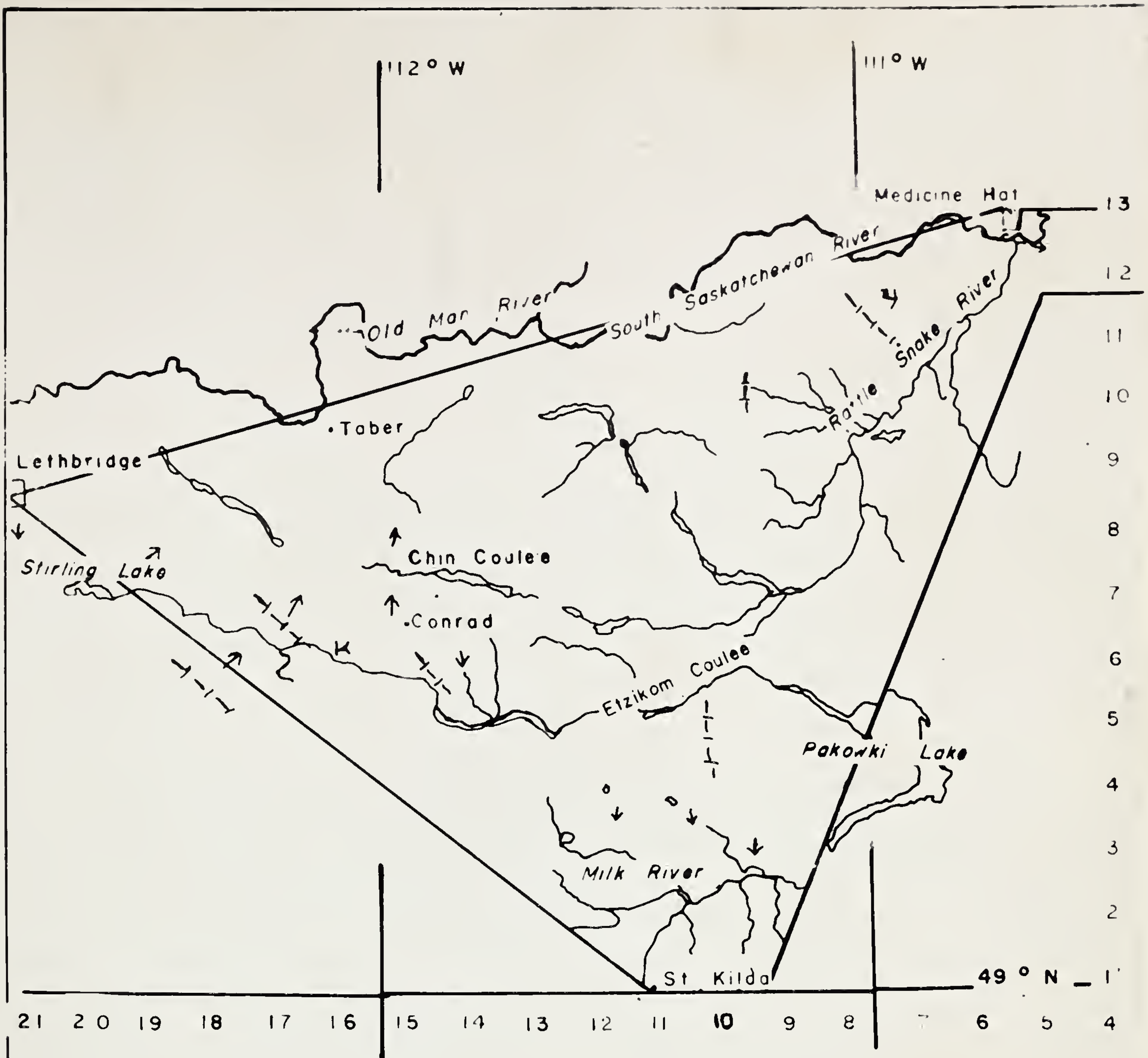


ALBERTA (HAIL AREA 6)

HAIL FREQUENCY, 1951–1960

Sections receiving hail three or more times during the period

SCALE
16 MILES TO 1 INCH



ALBERTA (HAIL AREA 6)

MAJOR PHYSICAL FEATURES

LEGEND

trend of valleys

hills or ridges

direction of slope

SCALE

16 MILES TO 1 INCH

MAP 21

Area 6.

(c) Cont'd.

3. aspect - southeast
4. very few lakes and streams, most of these intermittent
5. ridge follows a northeast to southwest orientation with hail on the southeast, not on the crest of the ridge

(d) Ranges 9 to 12; Township 3.

1. local relief 350 feet
2. elevation 2950 to 3300 feet, surface of the till is irregular with most hail occurring between 2950 and 3100 feet
3. aspect - slight tendency to be southeastern
4. numerous intermittent streams and sloughs
5. hail is found to be more frequent in the more level, as well as the lower, pockets within the area. e.g. southwest corner of range 9 and southeast corner of range 10 - township 3 - where the hail cluster occurs at approximately 3000 feet on the level area which has almost no relief

Area 6.

(e) Ranges 9 and 10; Townships 4 and 5.

1. local relief 150 feet
2. elevation 2900 to 3050 feet, gentle gradient
3. aspect - eastern
4. numerous intermittent streams and sloughs
5. low range of hills lies to the west, aligned north-south

(f) Ranges 9 and 10; Township 10.

1. local relief 100 feet
2. elevation 2700 to 2800 feet, very gentle slope, less than 100 feet in 7 miles
3. aspect - no distinct exposure
4. many intermittent sloughs, few streams
5. note the break of hail occurrence which corresponds with the highest section within the area

(g) Ranges 14 and 15; Township 6.

1. local relief 75 feet
2. elevation 3025 to 3100 feet, very gentle slope
3. aspect - gentle slope to south and east
4. many intermittent lakes and streams
5. northwest to southeast alignment

Area 6.

(h) Range 15; Township 8. (South of Taber.)

1. local relief 100 feet
2. elevation 2800 to 2900 feet
3. aspect - southern - where the gradient decreases and land becomes more level
4. intermittent streams and sloughs
5. hills tend to be aligned in an east-west direction with the hail occurring half way up the southern slope between Conrad and Taber on a small terrace

(i) Ranges 16 to 18; Townships 6 and 7.

1. local relief 100 feet
2. elevation 3100 to 3200 feet, gentle slope
3. aspect - northern, terrace half way up a hill rising to the south
4. numerous lakes to south and east of area
5. east-west alignment. Break between the two hail patches corresponds with a ridge of higher elevation which has a much more uneven and irregular surface than the areas receiving hail

Area 6.

(j) Range 19; Township 7.

1. local relief 50 feet
2. elevation 3050 to 3100 feet, almost flat
3. no particular exposure
4. no lakes or streams in immediate area but Etzikom Coulee and Stirling Lake to south
5. no particular alignment to hills

(k) Range 19; Township 8.

1. local relief 100 feet
2. elevation 3000 to 3100 feet, gentle slope
3. aspect - northern
4. one small intermittent stream
5. no apparent pattern to topographic features

(l) Range 21; Township 8.

1. local relief 125 feet
2. elevation 2900 to 3025 feet, gentle slope just below top of ridge
3. aspect - southern
4. Old Man River forms the eastern margin
5. valleys and hills east-west, hail track northwest - southeast

Area 7. (See maps 22 and 23.)

(a) Ranges 20 and 21; Township 38.

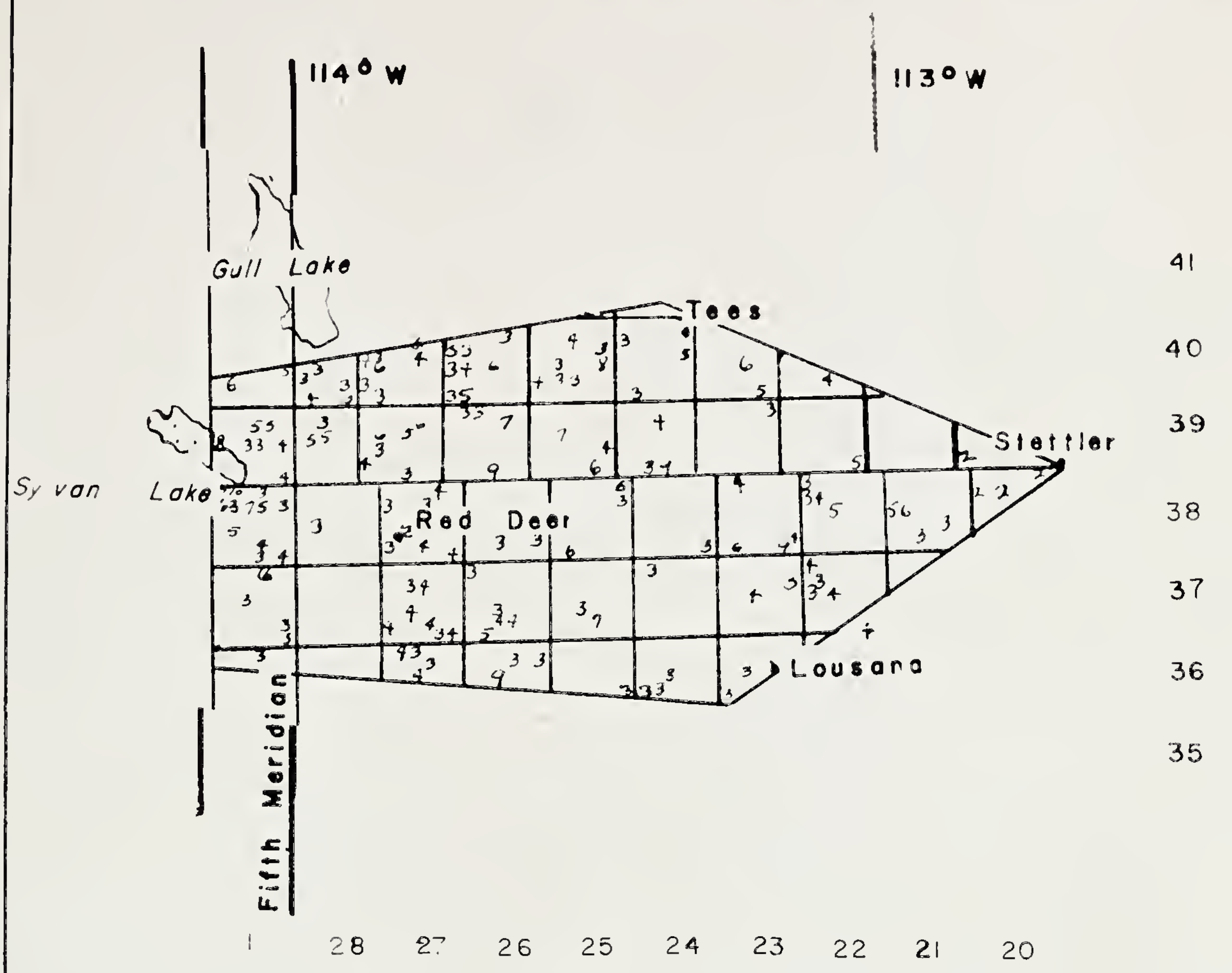
1. local relief 40 feet
2. elevation 2660 to 2700 feet
3. aspect - northern
4. few small lakes, Erskine Lake to the east
5. no particular alignment to hills

(b) Ranges 22 and 23; Townships 37 and 38.

1. local relief 100 feet
2. elevation 2800 to 2900 feet
3. aspect - northern
4. no lakes in immediate area
5. hail concentrated on the northern end, below the crest, of a north-south ridge

(c) Ranges 24 and 25; Township 36.

1. local relief 50 feet
2. elevation 2900 to 2950 feet
3. floor of valley at its broadest point
4. Pine Lake on the valley floor to the east of the hail
5. valley aligned northwest-southeast



ALBERTA (HAIL AREA 7)

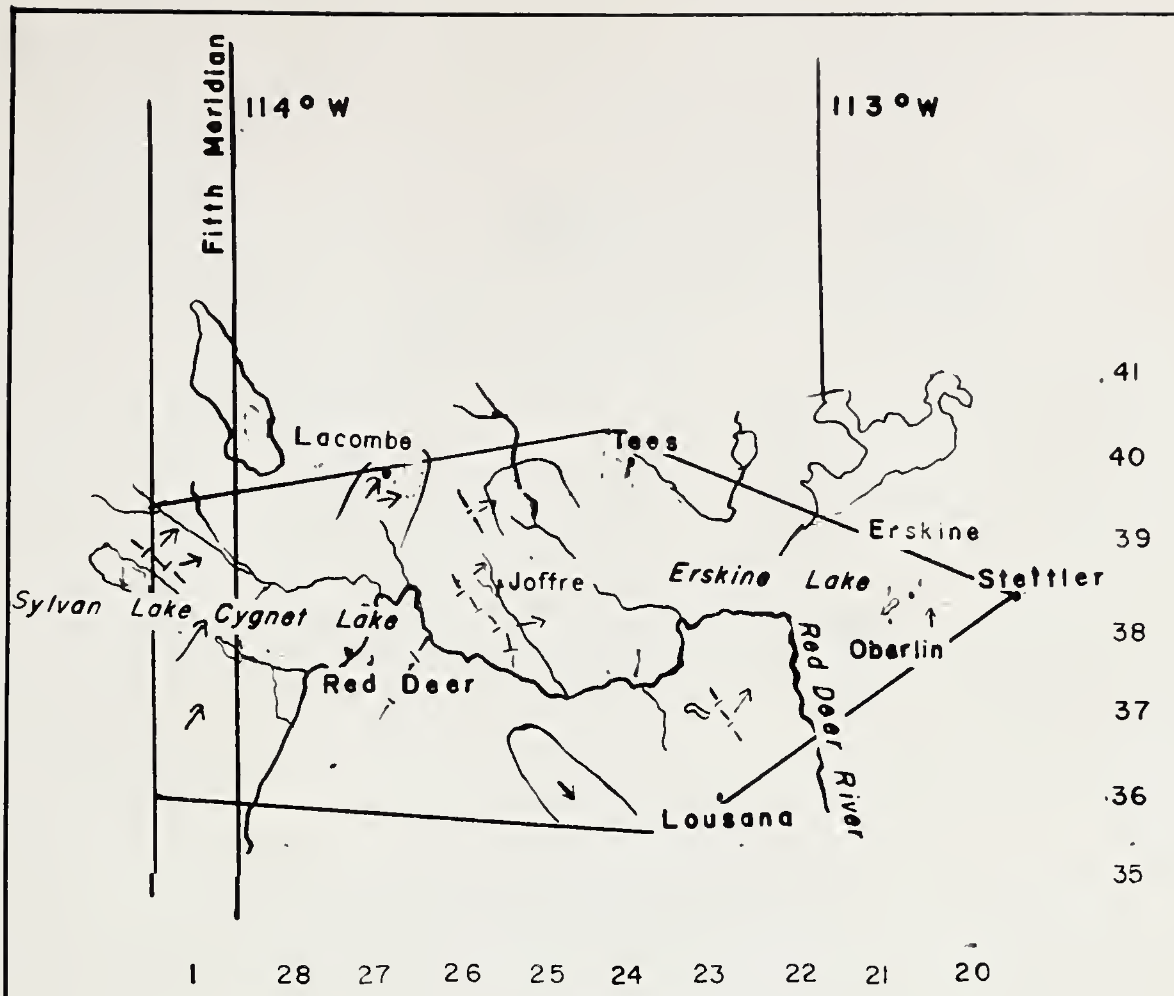
HAIL FREQUENCY, 1951–1960

Sections receiving hail three or more times during the period

SCALE

16 MILES TO 1 INCH

MAP 22



ALBERTA (HAIL AREA 7)

MAJOR PHYSICAL FEATURES

LEGEND

trend of valleys

hills or ridges

← direction of slope

SCALE

16 MILES TO 1 INCH

Area 7.

(d) Ranges 24 and 25; Townships 38 and 39.

1. local relief 100 feet
2. elevation 2800 to 2900 feet, gentle slope
3. aspect - northern, northeastern, and eastern
4. a few intermittent streams
5. hail track northwest to southeast, hail over crest of ridge

(e) Ranges 24 and 25; Township 40.

1. local relief 100 feet
2. elevation 2900 to 3000 feet
3. aspect - northern and eastern
4. no lakes or streams
5. area is broad and flat

(f) Ranges 26 and 27; Townships 36 to 38.

1. local relief 400 feet
2. elevation 2800 to 3200 feet, terrace of the Red Deer River
3. no direct exposure
4. no lakes, Red Deer River
5. hail along river valley on both banks but more on the western, valley runs north-south

Area 7.

(g) Ranges 26 to 28; Townships 39 and 40.

1. local relief 250 feet
2. elevation 2750 to 3000 feet
3. aspect - northern and eastern
4. Gull Lake northwest of hail concentration
5. storm track at the southern end of Gull Lake, southwest to north northeast

(h) Range 1; Townships 36 to 40, W. 5th.

1. local relief 200 feet
2. elevation 3000 to 3200 feet, flat except for township 39
3. aspect - none for most of the strip, northeastern on ridge north of Sylvan Lake
4. Sylvan and Cygnet Lakes, hail track between them
5. the ridge north of Sylvan Lake is aligned northwest to southeast, hail on northeastern slope

APPENDIX "C"

The information in this appendix is in tabular form, the object of the table being to show whether or not the subdivisions in the areas agree with the hypotheses established in the analysis of area 2c. The five columns represent the hypotheses and the detail shows whether or not the subdivision has the same features. The differences and degree of differences are indicated. For more detailed information and maps of the individual areas see Appendix "B"

T A B L E I

A R E A 2

SUBDIVISION	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R. 19; T. 30 a	Yes	Yes	Valleys at widest point slight W exposure	No Lakes	Alignment of valley to NW is more significant than W aspect
R. 20; T. 30 b	Yes	Yes	Southern	Few intermittent lakes	N-S ridge and W-E valley

AREA 2

SUBDIVISION	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.24; T.32 T.35 f	Yes	Yes	NE (north & central. SE (S)	Few small intermittent tributaries to Ghostpine Creek	West bank of Ghostpine Creek NNW - SSE
R.25 - 29 T.25 - 36 g	Irregular surface, hail following valleys where they are broad & avoiding lakes	Broad flat depressions appear to be the recipients of hail	E & S broad flat valleys	Lakes, but hail is not concentrated near them but rather away from them	Valley from Innisfail to Strathmore, NNW - SSE

A R E A 2

SUBDIVISION	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.1; W.5 T.25 - 36 h	Irregular gradient	Yes Note lack of hail on "The Nose" & hill near Bowden	E	Avoids lake areas	Valleys NW-SE

AREA 3

SUBDIVISION	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.13 & 14 T.16 a	Yes	Yes	E	None in area	Eastern slope of hills
R.12 - 14 T.17 & 18 b	Yes	None	Broad flat valley with no exposure	Hail tracks avoid lakes	NW - SE
R.14; T.19 T.20 c	Yes	None	Very flat regular surface	No hail around Lake Newell	Hail track N - S

AREA 3

SUBDIVISION	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.15; T.19 d	Yes	No hail on higher areas around depression	Basin or depression	Intermittent sloughs	Basin NS
R.16; T.16 T.17 e	Yes	Yes	Yes	No lakes Bow River	NS (S) & NW - SE (N) Bow River valley
R.18; T.16 T.17 f	Yes	Yes	E	Many intermittent sloughs & streams	Ridge NS

<u>A R E A 3</u>

	I	II	III	IV	V
SUBDIVISION	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
R.25 - 29 T.21 - 25 8	Yes	Yes	Surface very irregular with the hail seeking the lower places within the area	Streams & small widely scattered lakes	Storm track in NW - SE valley, Dalemead to Delacour

AREA 4

SUBDIVISION	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.14 - 16 T.42 & 43 a	Yes	Crest of ridge to S. of strip does not show hail	Broad flat strip NE slopes of ridge	Many very small lakes	NW - SE alignment E. of Battle River
R.15 & 16 T.47 & 48 b	Hail is greater where the gradient is 25 feet per mile than where the land is level	No crest in area	NE	Numerous swampy areas	Storm track SW - NE

AREA 4

	I	II	III	IV	V
SUBDIVISION	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREAS AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
R.15 & 16 T.49 & 50 c	Yes	No distinct crest in or immediately around the area	No definite aspect	A few swampy areas	Storm tracks SW - NE
R.16 - 20 T.43 & 44 d	Yes	Avoids crest & higher land, to south T.44 more hail	N & NE	A few small lakes	North slope ridge & valley into it, SW - NE tracks
R.18;T.45 T.46 e	Yes	Northward extension of area 4d	N	No lakes Driedmeat Creek	Valley NS

AREA 4

SUBDIVISIONS	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.20 - 24 T.46 f	Yes	Yes	N & NE	No lakes	Pipestone River W - E, S. of area
R.23 - 26 T.41 - 43 g	Yes	Almost none on the top of the knobs rough irregular surface, moraine	N NE E	A few small kettle lakes	No trend to valleys or hills

A R E A 4

	I	II	III	IV	V
SUBDIVISIONS	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
R.26 - 28 T.40 - 45 h	Yes	Northward extension of 7g	NE	Few small lakes	Track SW & NE
R.25 - 28 T.49 & 50 i	Yes	Yes	N	No lakes	N. Sask. River valley W - E, storm track same alignment
R.1 - W.5 T.40 - 44 j	Yes	Yes	E	Gull Lake, land around lake for about 12 miles is hail free	Hail strip SSW - NNE

A R E A 4X

	I	II	III	IV	V
SUBDIVISIONS	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
Within but not all of R.17 - 28 T.47 - 52 See maps 15 & 16	Yes	Yes	W pitted outwash	Many lakes	N - S moraine

A R E A 5

	I	II	III	IV	V
SUBDIVISIONS	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
R.13; T.13 a	Yes	Yes	SE	Several small lakes	Hail SW - NE hail road NW - SE
R.14; T.13 b	Yes	Yes	SE	None	
R.17; T.13 T.14 c	Yes	None	None	Intermittent lakes & sloughs	Broad flat basin

AREA 5

SUBDIVISIONS	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.19; T.12 d	Yes	Yes	E	None	N - S
R.19; T.13-15 e	Yes	Yes	E	2 permanent lakes	None
R.22; T.14 f	Yes	Yes	E	few intermittent streams	N - S Blackspring Ridge

AREA 5

	I	II	III	IV	V
SUBDIVISIONS	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
R.23; T.15 g	Yes	None	Basin	No lakes or streams in basin	North of an EW valley
R.25 - 29 T.16 - 22 h	Yes	Yes	Broad flat valley	A few intermittent lakes & streams	Valley NW - SE

AREA 6

SUBDIVISIONS	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.4; T.12 a	Yes	Yes	None	Numerous intermittent lakes & sloughs	Yes
R.5 - 6 T.12 b	Yes	Yes	Yes	Many intermittent sloughs & streams	No apparent trend
R.7 & 8 T.11 c	Yes	Yes	Southeastern	Very few intermittent lakes & sloughs	NW - SE

AREA 6

SUBDIVISIONS	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.9 - 12 T.3 d	Yes	Yes	SE	Numerous intermittent lakes & streams	No apparent trend
R.9 - 10 T.4 & 5 e	Yes	Yes	E	Numerous intermittent streams & sloughs	Hills to the west N - S
R.9 & 10 T.10 f	Yes	Yes	None in particular	Many intermittent sloughs, few streams	No apparent trend

A R E A 6

SUBDIVISIONS	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.14 & 15 T.6 g	Yes	Yes	S & E	Many intermittent lakes & streams	NW - SE
R.15; T.8 h	Yes	Yes	S	Intermittent streams & sloughs	E - W
R.16 - 18 T.6 & 7 i	Yes	2 patches of hail separated by a ridge	N	Numerous lakes to S. & E. of area	E - W

A R E A 6

	I	II	III	IV	V
SUBDIVISIONS	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
R.19; T.7 j	Yes	Almost flat	None in particular	None	None
R.19; T.8 k	Yes	Almost flat	N	One small intermittent stream	No apparent trend
R.21; T.8 1	Yes	Yes	S	Old Man River to E	Hail track NW - SE

A R E A 7

SUBDIVISIONS	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.20 & 21 T.38 a	Yes	No Crest	Northern but not distinctive	A few small lakes	No particular pattern
R.22 & 23 T.37 & 38 b	Yes	Just below crest of ridge	Northern end of a N-S ridge	None	Not on floor of valley, gradient steeper
R.24 & 25 T.36 c	Yes	Yes	No direct exposure	Lake on valley floor hail to E of it	Floor of valley where it broadens NW - SE

A R E A 7

	I	II	III	IV	V
SUBDIVISIONS	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS
R.24 & 25 T.38 & 39 d	Yes	Yes	N NE E	A few intermittent streams	NW - SE ridge
R.24 & 25 T.40 e	Yes	Yes	N & E	No lakes or streams	Valleys broad & flat
R.26 & 27 T.36 - 38 f	Yes	Yes	No direct exposure	Red Deer River	Along river valley both banks but mostly western, N-S

AREA 7

SUBDIVISIONS	I SLOPES TEND TO BE GENTLE	II TOPS OF RIDGES HAIL FREE	III EASTERN ASPECT	IV AREA AROUND LAKES HAIL FREE	V TRACKS FOLLOW BROAD FLAT VALLEYS
R.26 - 28 T.39 & 40 g	Yes	No ridge broad flat area S & E of lake	N & E	Gull Lake NW of concentration	SSW - NNE storm track around S end of lake
R.1; W.5 T.36 - 40 h	Yes	Yes	Very flat except on NE slope of ridge	Sylvan Lake & Cygnet Lake hail track between them	Flat, note ridge N of Sylvan Lake, hail on NE slope

A R E A 1

SUBDIVISION	SLOPES TEND TO BE GENTLE	TOPS OF RIDGES HAIL FREE	EASTERN ASPECT	AREA AROUND LAKES HAIL FREE	TRACKS FOLLOW BROAD FLAT VALLEYS

The patterns seen earlier tend to reappear here and no contradictions are apparent. For more information see maps and discussion in Appendix "B".